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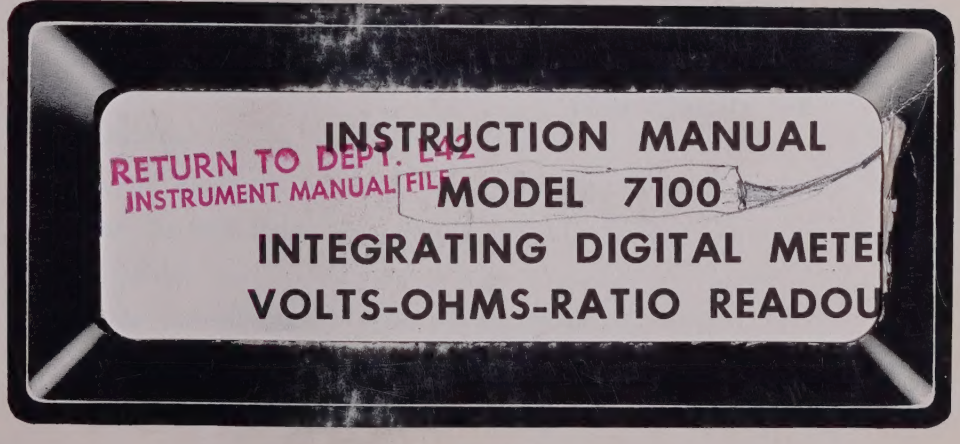

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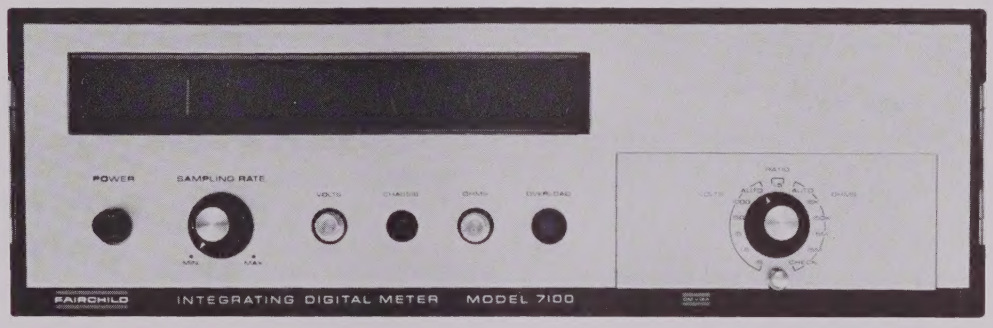

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INSTRUCTION MANUAL
MODEL 7100
INTEGRATING DIGITAL METER
VOLTS-OHMS-RATIO READOUT

FAIRCHILD INSTRUMENTATION — WESTERN OPERATIONS

A Division of Fairchild Camera and Instrument Corporation

844 Charleston Road Palo Alto, California

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LIST OF EFFECTIVE PAGES

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FAIRCHILD SEMICONDUCTOR (INSTRUMENTATION)

EQUIPMENT WARRANTY

Seller warrants equipment of its manufacture against defective materials or workmanship for a period of one year from date of shipment.

The liability of Seller under this warranty is limited, at Seller's option, solely to repair, replacement with equivalent Fairchild equipment, or an appropriate credit adjustment not to exceed the original equipment sales price, of equipment returned to the Seller provided that:

(a) Seller is promptly notified in writing by Buyer upon discovery of defects,

(b) The defective equipment is returned to Seller, transportation charges prepaid by Buyer, and,

(c) Seller's examination of such equipment discloses to its satisfaction that defects were not caused by negligence, misuse, improper installation, accident, or unauthorized repair or alteration by the Buyer.

This warranty does not include mechanical parts failing from normal usage nor does it cover limited life electrical components which deteriorate with age such as vacuum tubes, chopper, lamps, etc. In the case of accessories, i.e., card punches, typewriters, etc., not manufactured by the Seller, but which are furnished with the Seller's equipment, Seller's liability is limited to whatever warranty is extended by the manufacturers thereof and transferable to the Buyer.

This warranty is applicable to the original Buyer only and constitutes the sole and exclusive warranty of Seller.

No other warranty is made, expressed or implied.

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION

1-3. This manual provides information for installation, operation and maintenance of the Fairchild Model 7100 Integrating Digital Meter. Section I includes a general description of the instrument together with a table of specifications. Section II includes installation instructions. Section III discusses front panel controls and operating procedures. Section IV includes operating theory. Section V provides information for checking performance and making adjustments. Section VI lists replacement parts.

1-3. GENERAL DESCRIPTION

1-4. The Model 7100 is an integrated circuit DVM that operates on a new dual slope integrating technique. It is a self-contained, portable bench top or rack-mount unit providing 5-digit visual readout and binary-coded decimal print information. The Model 7100 gives direct readout of voltages from 10 microvolts to 1000 volts, resistance from 1 ohm to 15.000 megohms, and voltage ratios from 0.0001:1 to 1.5000:1. Certain single test capabilities or combinations of tests may be specified in the Model 7100. These instruments are identified by an additional model number marked on the serial number tag at the rear of the instrument. The limited readout versions available are listed as follows:

Model 7110 - Volts, ohms
Model 7120 - Volts, ratio
Model 7140 - Volts
Model 7160 - Ratio

1-5. Automatic ranging on volts and ohms is available as an option; the ranging logic being mounted on a plug-in board which is installed into a connector fitted on all versions of the instrument. The meters fitted with auto ranging are identified by a model number marked on the serial number tag. The auto ranging versions available are listed as follows:

Model 7101 - Volts, ohms, ratio
Model 7111 - Volts, ohms
Model 7121 - Volts, ratio
Model 7141 - Volts

1-6. This manual contains information on the basic Model 7100 with volts, ohms, and ratio readout. The modifications incorporated in this instrument to achieve the limited readout capabilities of the other Models available are fully detailed in Appendices A through D. Appendix E provides detailed information on the optional auto-

Figure 1-1 Model 7100 Integrating Digital Meter and DM01A Plug-In

matic ranging facility.

1-7. To provide flexibility, separate floated and guarded input connections are used for voltage and resistance measurements. The input circuit incorporates a non-linear protection device that prevents damage and gives quick recovery from overloads. An additional rear connector is used for a voltage input for ratio measurements. Range and measurement mode controls can be remotely programed through a rear connector if desired. The standard plug-in provides manual/auto and mode selection from a single control. Additional plug-ins are available to provide ac/dc conversion, and high Z-input performance.

1-8. The use of integrated circuits provides unequaled reliability and long-term, high integrity performance. The operational amplifier used in the Model 7100 is equivalent to the Fairchild Instrumentation A00-10 unit. This incorporates the Goldberg drift-reduction scheme, which combines the excellent low-drift characteristics of a chopper stabilized amplifier with the high-speed characteristics of a differential amplifier. Photoelectric chopping is utilized in the A00-10 amplifier. This eliminates the need for mechanical choppers with the lowest rated life of any component normally

found in a DVM. This greatly improves system reliability.

1-9. The use of micrologic elements for control and gate circuits and the solid-state A00-10 type amplifier assures ultra-fast repeatable precision operation. Also, for the first time test results can be obtained without frequent calibration.

1-10. The basic theory of operation of the measuring circuit is as follows: a current, which is proportional to the unknown input voltage charges a capacitor during a fixed period of time, determined by a continuous oscillator (e.g. during 10,000 cycles). The capacitor is then discharged by a second current, which is proportional to the second input voltage (reference voltage). The number of oscillator cycles during the discharge time is proportional to the ratio of the first input voltage to the reference voltage. This unique integrating dual slope measuring technique eliminates the integrator as a "critical circuit", by cancelling out effects of drift and long term variation in integrating capacitance, resistance and clock oscillator frequency. The technique also provides noise rejection independent of peak height and zero cross-over. Another advantage of the circuit is that there is no jitter in the least significant digit (unless the parameter under test is changing).

1-11. Two-thirds of the transistors in the Model 7100 are contained in integrated circuits. All circuitry is mounted in only 11 printed circuit cards, with eight cards located within the guarding box. In-cabinet space is available for custom adaptation for system applications.

1-12. APPLICATIONS

1-13. The Model 7100 Tester is recommended for the following applications:

a. Wherever high-accuracy measurements are required, especially in the presence of noise.

b. Continuous-duty applications which demand a minimum of calibration.

c. Rapid, low drift readout for production line and inspection stations.

d. Long or short-term monitoring of 4-digit parameters.

e. Go no-go testing.

f. System applications.

1-14. ELECTRICAL SPECIFICATIONS

1-15. Table 1-1 contains electrical specifications for a Model 7100 fitted with standard DM-01A plug-in. Electrical specifications for optional plug-ins are contained in the instruction manuals for these units.

Table 1-1 Model 7100 Electrical Specifications

VOLTAGE MEASUREMENT

Ranges	Accuracy	Input Impedance	Measurement Time
±1000.0 volts ±150.00 volts ±15.000 volts ±1.5000 volts	±0.01% of reading ±1 digit	1.0 megohm	50 ms, maximum (includes polarity change)
±150.00 millivolts	±0.01% of reading ±2 digits	100 kΩ	250 ms, max. (includes polarity change)

Note: The maximum input on the ±150.00 millivolt range is ±300 volts (±500 volts on auto ranging). Any voltage in excess of these values may damage the instrument.

VOLTAGE RATIO MEASUREMENT:

Range*	Accuracy	Unknown Input	Reference Input
±1.5000	±0.01% of reading ±1 digit with 10 v reference; ±0.02% of reading ±1 digit with other reference voltages between +5 v and +15 v	1 millivolt up to 15 v, either polarity; input impedance 1.0 megohm	+5 v to +15 v; 3 kΩ input impedance

*Automatic polarity indication

RESISTANCE MEASUREMENT:

Ranges	Accuracy	Measurement Time
15000 kilohms 1500.0 kilohms 150.00 kilohms 15.000 kilohms	±0.02% of reading ±1 digit	50 milliseconds, maximum

Table 1-1 Model 7100 Electrical Specifications (Cont)

TEMPERATURE CHARACTERISTICS:	
Operating Temperature Range:	10°C to 50°C
Temperature Stability (over-all, including reference drift and other effects):	±0.08 digits per °C (zero drift) ±0.002% of reading per °C (temperature coefficient)
Reference Voltage Stability:	Compensated to better than ±0.0005% per °C
NOISE REJECTION:	
Input Circuit Type:	Floated and guarded; may be operated at up to 500 v from chassis ground. Uses special 2-pin insulated BNC connector for HI, LO, and GUARD circuits; separate banana jack for chassis ground.
Common Mode Rejection:	140 db at dc; 120 db up to 1000 cps; with up to 1000 ohms line unbalance
Normal (Superimposed):	True-integration measurement technique rejects all noise which averages to zero over the measurement interval. Noise peaks may exceed signal level, and zero crossovers are permissible.
READOUT PROVISIONS:	
Visual:	Amperex ZM-1030 numeric tubes; four full decades plus fifth-digit over-range, plus polarity and measurement unit with decimal.

Table 1-1 Model 7100 Electrical Specifications (Cont)

READOUT PROVISIONS: (Cont)

Electrical* (for printer drive or system applications, etc.):	Digital Readout:	BCD (122*4 code), four lines per decade; "0" state level is +0.5 v, "1" state level is +30 v; 20 k source impedance.
	Decimal Point Readout:	BCD (122* code), same levels as above.
	Polarity Readout:	"0" for +, "1" for -; "0" state level is +0.5 v, "1" state level is +15 v. Source impedance 11 kΩ.
	Print Command:	+30 volt pulse

*Provided through rear connector

REMOTE PROGRAMING PROVISIONS*:

Range and Mode Selection:	External NPN transistor gate or contact closure to ground corresponding to selected switch position. Load current is 60 ma in closed contact. Voltage across open contact is 30 volts.
Measurement Cycle Start:	External pulse in lieu of jumper used to complete local automatic start pulse

*Provided through rear connector

POWER REQUIREMENTS:

Standard: 105 - 125 volts or 210 - 250 volts (conversion provided by chassis switch), 50 - 60 Hz; approximately 50 watts.

1-16. PLUG-IN MODULES

1-17. The following plug-in modules, one or more of which should be selected for use with the basic unit, are available:

a. Standard Module DM-01A
b. High Input Impedance Converter DM-02
c. AC to DC Converter DM-03

1-18. MODEL NUMBER SUMMARY

1-19. Table 1-2 lists the total number of Model 7100 readout versions available at the present time. In all cases, "Model 7100" is marked on the front panel of the instrument, and an additional number, identifying the readout mode(s) of operation is stamped on the serial number tag located on the rear panel of the meter.

Table 1-2 Model Number Summary

Model Number (Rear Panel)	Readout Capability	Range Selection
7100	Volts, Ohms, Ratio	Manual
7101	Volts, Ohms, Ratio	Manual/Auto
7110	Volts, Ohms	Manual
7111	Volts, Ohms	Manual/Auto
7120	Volts, Ratio	Manual
7121	Volts, Ratio	Manual/Auto
7140	Volts	Manual
7141	Volts	Manual/Auto
7160	Ratio	Manual

1-20. MECHANICAL DATA

1-21. The unit may be cabinet or rack mounted; the basic cabinet design permits rack mounting by simple attachment of optional front panel flanges and drawer slides. The rack-mount flanges provide front handles for the rack-mount configuration. The basic cabinet includes recessed strap-type carrying handles on the sides and a tilt bail that allows the instrument to be set to a convenient table-top viewing angle.

1-22. DIMENSIONS AND WEIGHT

1-23. Figure 1-2 is an outline drawing of the Model 7100 showing principal dimensions in inches and centimeters. The weight of a Model 7100 with DM-01 plug-in is 23.4 lbs. (10.6 kg).

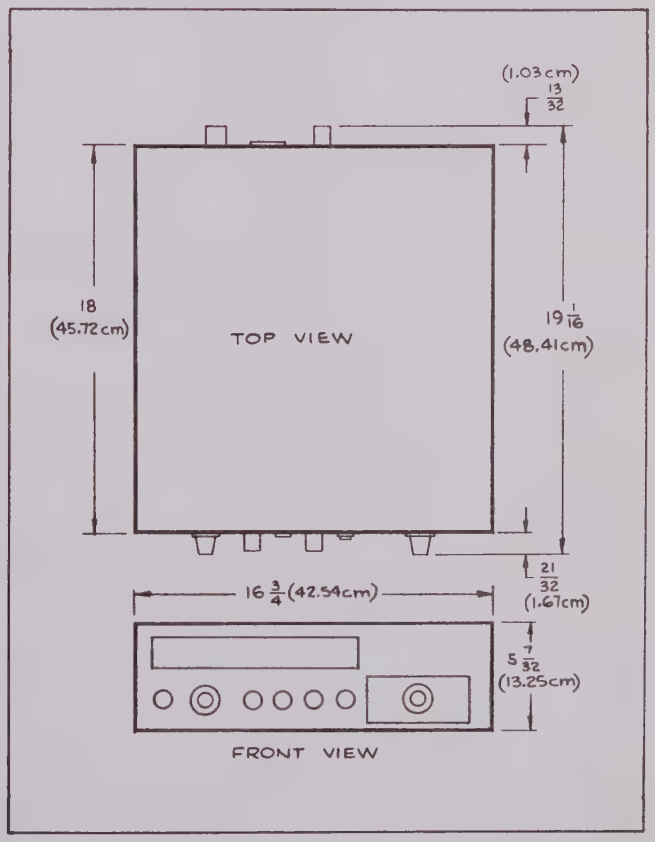


Figure 1-2 Model 7100 Outline Drawing

SECTION II
INSTALLATION

2-1. SCOPE OF SECTION

2-2. This section contains instructions for initial installation and inspection of the Model 7100. In addition, reshipment instructions are provided in the event that the instrument must be returned to Fairchild Instrumentation.

2-3. PREPARATION FOR USE

2-4. The following paragraphs describe the procedures required to prepare the instrument for use. These instructions include: unpacking, inspection, connecting to a power source, and performance check.

2-5. UNPACKING

2-6. Before releasing the carrier, inspect the packed unit for any sign of external damage. If damage is noted, it should be called to the attention of the carrier and noted on the receiving receipt. Do not proceed with unpacking until instructed to do so by the authority of the insuring agency.

2-7. INSPECTION

2-8. With instrument unpacked, remove upper and lower cover plates and make a careful inspection to ensure that there is no concealed physical damage to internal circuits or components.

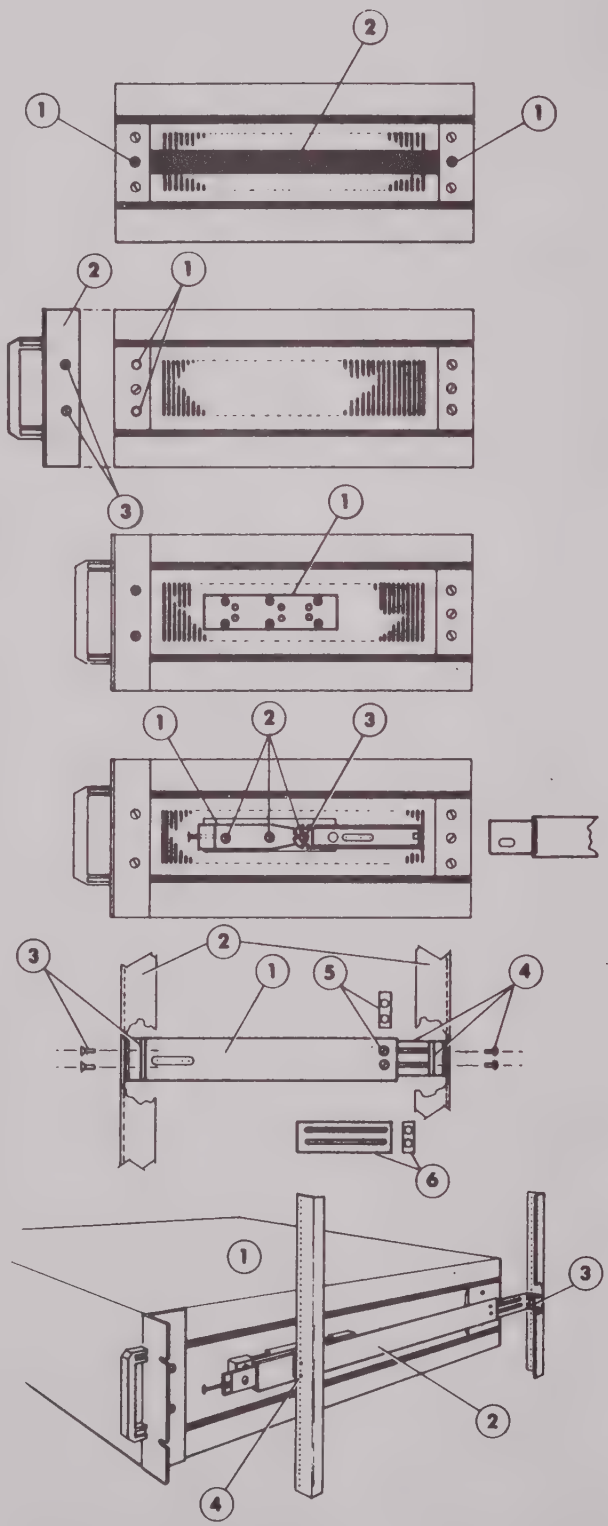
2-11. Ensure that all plug-in components are firmly seated in place. Replace upper and lower cover plates.

2-12. POWER CORD

2-13. The Model 7100 is supplied with a detachable 3-conductor power cable which is terminated with a polarized 3-prong male connector at one end and a female conductor at the other. The off-set round pin is the ground connected to the instrument chassis. The female connector fits the 3-pronged socket at the rear of the chassis. If a 2-contact outlet is used as the power source, it is recommended that a 3-prong to 2-prong adapter be used and the short lead on the adapter connected to ground.

2-14. 230 VOLT OPERATION

2-15. To convert the Model 7100 to operation from a 230-volt 50/60 Hz ac source, remove upper cover and set switch S2 to 230 v position. (The switch is located at the rear of the chassis adjacent to the power transformer). Replace fuse F1 (1 amp) with 1/2 ampere fuse.



a. Remove screws (1) and handle strap (2). Replace screws.

b. Remove screws (1) from front of instrument. Place rack handle (2) in position and replace screws with flat head screws.

c. Mount adapter (1) using six no. 4 screws. Note spacing on detail.

d. Remove center section (1) from slides. Mount adapter in lower set of holes using shoulder screws (2). Use screw with longer shoulder for pivot point (3).

e. Mount front of slide with flat head screws and bar nut (3). Mount angle bracket (4) using binder head screws and bar nut (5). If additional length is required use expander plate (6). Do not secure screws tightly at this time.

f. Place instrument (1) in rack (2) and insert fully into rack. Tighten screws (3) at rear. Withdraw instrument approximately six inches and adjust rack until it is level. secure screws (4) on front.

Figure 2-1 Rack Mount Conversion Instructions

2-16. NORMAL/REMOTE OPERATION

2-17. The Model 7100 as delivered is set up for normal operation whereby all functions of the instrument are controlled by the front panel controls. Instructions for changing to remote control are contained in paragraphs 3-18 through 3-27 of this manual.

CAUTION

THE TWO JUMPERS MOUNTED ON PLUG P2 SITUATED AT THE REAR OF THE INSTRUMENT ARE REQUIRED FOR NORMAL OPERATION AND THEIR REMOVAL, WITHOUT THE ADDITION OF THE NECESSARY REMOTE PROGRAMING INPUTS, WILL DISABLE THE INSTRUMENT.

2-18. PERFORMANCE CHECK

2-19. A quick check to determine whether the instrument will function correctly may be made by carrying out the following steps:

a. Connect instrument to ac power source and set POWER switch to ON position. Check that POWER indicator lights.

b. Set Range/Function switch to CHECK position.

c. Plug signal input cable into front panel VOLTS jack. Connect LO and GUARD jacks on cable together. (See figure 3-3).

d. Check that readout indicates 10000 ±1 digit. If this is not the case consult table 5-5.

NOTE

Failure to connect the LO and GUARD terminals together, as instructed in paragraph 2-19c, may cause an erroneous readout.

2-20. Detailed performance checks are described in paragraphs 5-5 through 5-12.

2-21. RACK MOUNT CONVERSION

2-22. Detailed instructions for converting the Model 7100 to a rack mounted assembly with the optional front flanges and drawer slides are contained in figure 2-1.

2-23. RESHIPMENT

2-24. When an instrument is damaged in shipping, the insurance investigator can order it returned. The responsibility for recrating and reshipment is insurance company's. Neither the customer or Fairchild are required to assume such responsibility without specific understanding with the insurance company through proper representatives.

2-25. When an undamaged operational tester is to be returned, an agreement will be made between Fairchild and the customer as to procedure.

SECTION III
OPERATION

3-1. SCOPE OF SECTION

3-2. This section defines the functions of the front and rear panel controls on a Model 7100 Integrating Digital Meter fitted with standard plug-in module DM-01A and optional ranging plug-in board A19. Also given are instructions on how to perform voltage, voltage ratio, and resistance measurements on a local and remote basis. Information concerning the use of the Model 7100 with optional high impedance module DM-02 and AC to DC converter module DM-03 is contained in the manuals for these units.

3-3. OPERATING CONTROLS

3-4. The function of the controls located on the front panels of Model 7100 and DM-01A are defined as follows: (See figure 3-1).

a. POWER switch connects ac power to instrument. A red indicator incorporated in switch lights when primary power is applied.

b. SAMPLING RATE potentiometer controls recurrence rate of measurement cycle. Rate may be varied from one every two seconds (MIN) to four per second (MAX). The action of the internal rate generator may be disabled and the measurement cycle triggered from an external source.

c. VOLTS coaxial jack is a special guarded BNC connector used (with test cable) for voltage measurements.

d. CHASSIS banana jack is connected to instrument chassis and ac power ground.

e. OHMS coaxial jack is a special guarded BNC connector used for resistance measurements.

f. Function/Range 13-position rotary switch sets measurement mode and readout range limits as follows:

VOLTS	.15	±.15000 volts (max. input ±300 v)
	1.5	±1.5000 volts
	15	±15.000 volts
	150	±150.00 volts
	1000	±1000.0 volts
	AUTO	Instrument automatically selects correct voltage range before starting measurement cycle. (Optional auto ranging plug-in board A19 required). A 2-position switch on A19 selects number of voltage ranges included in ranging process---150 MV setting allows ranging on all five ranges, 1.5 V setting cuts out lowest range. (This feature is provided as the input limit on the

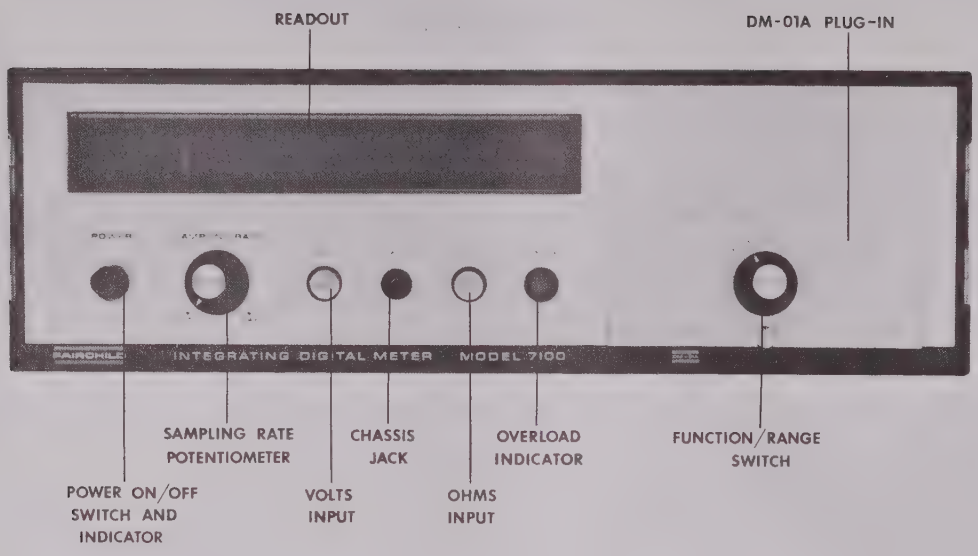


Figure 3-1 Model 7100 Front Panel

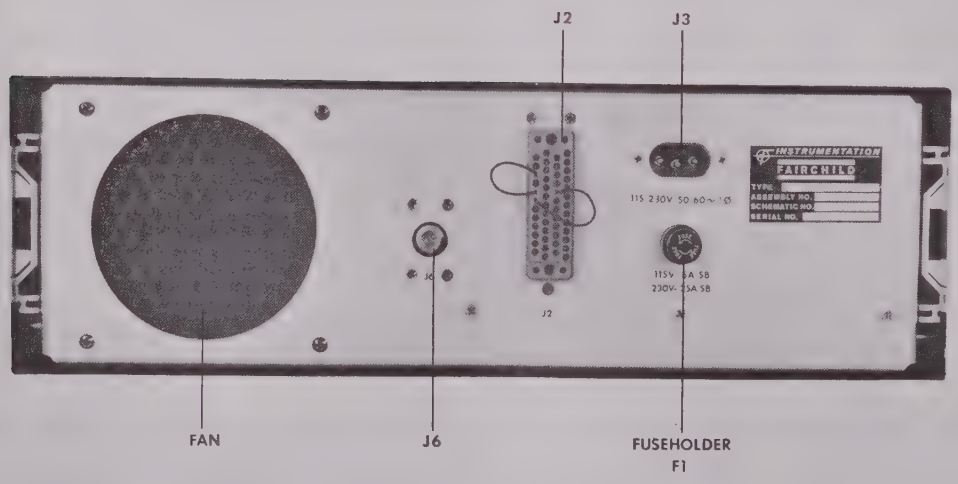


Figure 3-2 Model 7100 Rear Panel

		lowest voltage range during automatic ranging is ±500 volts and ±1000 volts on all others. Also, the input impedance is 100 kΩ on the lowest range and 1MΩ on the others. The instrument is delivered with switch set to 1.5v.)
RATIO	1.5	Voltage ratio ±1.5000:1
OHMS	AUTO	Instrument automatically selects correct resistance range before starting measurement cycle.
	15K	15.000 kilohms
	150K	150.00 kilohms
	1.5M	1500.0 kilohms
	15 M	15000 kilohms
CHECK		A self-check feature that gives a readout of 10000 when instrument is operating correctly.

All positions of the Function/Range switch may be remotely programed.

g. OVERLOAD indicator lights when signal applied to input of instrument exceeds manual range position set on Function/Range switch. Indicator is disabled in automatic ranging mode of operation.

h. Readout gives a 5-digit readout of test result. Polarity, decimal point, and readout units are also presented. On instruments with limited readout capabilities, selection of modes other than those performed by meter blanks out 5-digit decimal readout.

3-5. The purpose of the connectors fitted on the rear panel are as follows. See figure 3-2.

a. J2 50-pin connector provides: a) 122*4 binary-coded-decimal output of readout digits b) 122* binary-coded-decimal output of decimal point position c) remote control programing lines.

b. J3 3-terminal female socket as ac-power input receptacle.

c. J6 coaxial connector is BNC guarded jack for external reference voltage required for voltage ratio mode of operation.

d. F1 fuse-holder contains a 1 ampere fuse connected in ac primary input circuit. (0.5 ampere fuse for 230 volt operation).

3-6. TEST CABLE

3-7. The signal input cable terminates in three banana plugs colored red, black and white. The red pin is signal high, the black pin is signal low, and the white pin is guard. See figure 3-3. The other end of the cable is terminated with a special BNC coax-

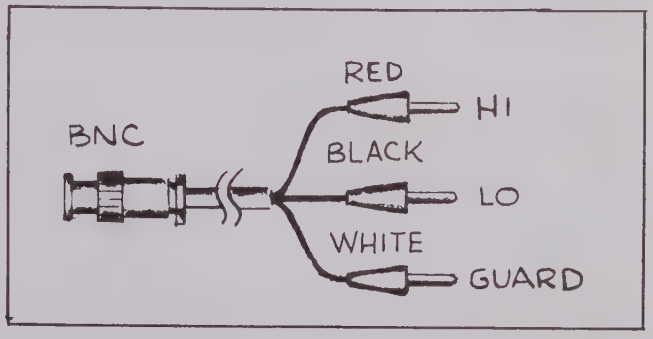


Figure 3-3 Signal Input Cable

ial plug that fits the VOLTS, OHMS and J6 connectors on the instrument.

NOTE

1. The test cable should be used at all times as substitution of it with wire and connectors having inferior leakage characteristics is liable to produce readout errors. This is especially important on the highest resistance range where a leakage of 15 kMΩ will give a 1 digit error.

2. To realize the full capabilities of the common-mode rejection circuitry incorporated in the design of the Model 7100, it is important that the three terminals on the cable be correctly employed. When measuring a low level high impedance source with its own ground (bridge transducer, thermocouple, etc.), connect the guard jack to the device ground and the high and low jacks to the output terminals. For all other measurements, connect the guard and low jacks to one side of the element under test, and the high jack to the other.

3-8. VOLTAGE MEASUREMENT - MANUAL RANGE SELECTION

3-9. To measure voltages between 10 microvolts and 1000 volts, operate instrument as follows:

a. Connect meter to ac power source. Set power switch to ON.

b. Set Function/Range switch to appropriate VOLTS range.

CAUTION

THE MAXIMUM INPUT ON THE LOWEST RANGE (150 MV) IS ±300 VOLTS. ANY INPUT IN EXCESS OF THIS VALUE MAY DAMAGE THE INSTRUMENT.

c. Connect test cable to VOLTS coaxial jack on front panel. Hook up test cable to unknown voltage source.

d. Set SAMPLING RATE fully clockwise to MAX position and observe readout.

NOTE

If OVERLOAD indicator is lit, progressively select higher range settings until light is extinguished.

3-10. VOLTAGE MEASUREMENT - AUTO RANGING

3-11. To measure voltages between 10 microvolts and 1000 volts, carry out following steps:

a. Set power switch to OFF.

b. Remove top cover of instrument and set low range limit switch S1 on plug-in board A19 to desired position.

NOTE

Switch S1 controls the lowest range from which the instrument begins its volts auto-ranging operation. The 150 MV position starts ranging from the lowest range (150 MV) and the 1.5 V position begins ranging from the 1.5 V range. The setting of S1 is important as the maximum input on the lowest voltage range during auto-ranging is 500 volts. (1000 volts on the remaining four ranges.) Thus, if the input voltage is unknown, an initial setting to the 1.5 V position is recommended. The instrument is delivered with S1 set to this position.

c. Replace cover and set power switch to ON.

d. Connect test cable to unknown voltage source and observe readout.

3-12. VOLTAGE RATIO MEASUREMENT

3-13. To perform voltage ratio measurement within range 0.0001:1 to 1.5000:1 proceed as follows:

a. Connect unknown input voltage to VOLTS jack on front panel and external reference voltage to J6 at rear of instrument. In both cases connect guard and low terminals to one side of voltage source and high terminal to other.

CAUTION

THE INPUT VOLTAGE MUST BE WITHIN THE RANGE OF 1 MILLIVOLT TO 15 VOLTS, EITHER POLARITY; AND THE REFERENCE INPUT +5 VOLTS TO +15 VOLTS. A REFERENCE VOLTAGE IN EXCESS OF 30 VOLTS WILL DAMAGE THE INSTRUMENT.

b. Set Function/Range switch to RATIO 1.5. Readout is presented as ratio of V_{in}/V_{Ref} (E1/E2) with polarity automatically indicated.

3-14. RESISTANCE MEASUREMENT - MANUAL RANGE SELECTION

3-15. To measure resistance within range 1 ohm to 15000 kilohms, operate meter as follows:

a. Plug test cable into OHMS coaxial jack on front panel and connect to unknown resistance. Connect guard and low jacks to one side of resistance, high terminal to other side.

CAUTION

IF TEST CABLES ARE IN USE AT BOTH THE "VOLTS" AND "OHMS" INPUT CONNECTORS (FOR EXAMPLE WHEN THE METER IS INCORPORATED WITHIN A SYSTEM), THE FOLLOWING PRECAUTIONS SHOULD BE OBSERVED: 1) ANY VOLTAGE OF MORE THAN 30 VOLTS INADVERT-

ANTLY APPLIED ACROSS THE "OHMS" TERMINALS WILL DAMAGE THE INSTRUMENT. 2) THE GUARD TERMINAL ON EITHER THE VOLTS OR OHMS CABLE SHOULD BE LEFT FLOATING. FAILURE TO OBSERVE THIS RULE WILL RESULT IN SATURATION OF THE INPUT AMPLIFIER CAUSING THE CORRECT READOUT TO BE DELAYED. THIS IS ESPECIALLY IMPORTANT WHEN THE MEASUREMENT CYCLE IS BEING TRIGGERED EXTERNALLY ON A "ONE-SHOT" BASIS.

b. Set Function/Range switch to appropriate OHMS range and observe readout.

NOTE

If OVERLOAD indicator is lit, progressively select higher range settings until light is extinguished.

3-16. RESISTANCE MEASUREMENT - AUTO RANGING

3-17. To measure resistance within the range of 1 ohm to 15000 kilohms, observe following instructions:

a. Set Function/Range switch to OHMS AUTO.

b. Connect test cable as detailed in paragraph 3-14 and observe readout.

NOTE

To ensure instrument accuracy in the highest range (15 MΩ), perform following steps: a) disconnect OHMS guard from OHMS low on ohms test cable and b) connect VOLTS low and VOLTS guard together on VOLTS input connector. (This is not necessary for OHMS manual mode of operation--use OHMS test cable in normal manner.)

3-18. REMOTE READOUT

3-19. Connector J2 at the rear of the instrument provides remote readout lines for data logging, systems applications, etc. The information is in parallel form and consists of a) 5-digit readout in 122*4 binary-coded-decimal b) decimal point data in 122* BCD c) polarity data and d) a print command signal. See table 3-1. The "0" state level on a line is +0.5 volts and the "1" level +30 volts. The source impedance is 20 kΩ. A mating connector (Winchester type MRAC-50P-JTD-H8) for J2 is supplied with the instrument. To use this connector, additional removeable contacts are required, corresponding to the wire size to be used in the cable. The contacts can be obtained from Winchester Electronics, Inc., Oakville, Connecticut.

3-20. REMOTE PROGRAMING

3-21. Connector J2 at the rear of the instrument also provides connections for remote programing a) mode and range selection and b) measurement cycle "start".

Table 3-1 J2 Remote Readout Data

Readout	Code	J2 Pin Desig.	Remarks
10,000's		y	0 = 0 (+.5 v) 1 = 1 (+30 v)
1,000's	1 2 2* 4 BCD	u v x w	122*4 Decode: 4-2*-2-1 0 = 0 0 0 0 1 = 0 0 0 1 2 = 0 0 1 0 3 = 0 0 1 1 4 = 0 1 1 0 5 = 0 1 1 1 6 = 1 1 0 0 7 = 1 1 0 1 8 = 1 1 1 0 9 = 1 1 1 1
100's	1 2 2* 4 BCD	p r t s	
10's	1 2 2* 4 BCD	z m k n	
unit's	1 2 2* 4 BCD	e f j h	
Decimal Point	1 2 2* BCD	R P N	122* Decode: 2*-2-1 XXXXX = 0 0 0 XXXX.X = 0 0 1 XXX.XX = 0 1 0 XX.XXX = 0 1 1 X.XXXX = 1 1 0 .XXXXX = 1 1 1
Polarity		BB	+ = 0 - = 1
Print Command		CC	+30 pulse

3-22. REMOTE MODE/RANGE SELECTION

3-23. To set instrument for remote selection of mode and range proceed as follows:

a. Remove jumper connected between pins M and W on plug P2. (This jumper is required for normal operation - removing it disables the Function/Range switch on the manual plug-in assembly.

b. Connect external NPN transistor gate or contract closure to ground to selected programing line on J2. See table 3-2. Load current is 60 ma in closed contact. Voltage across open contact is +30 volts.

Table 3-2 J2 Remote Function/Range Programing

Function/ Range	J2 Pin Designation	Remarks
VOLTS .15V	AA	Ground J2 pin for desired Function/Range switch position
1.5V	A	
15V	B	
150V	C	
1500V	D	
AUTO		
RATIO 1.5	E	
OHMS AUTO		
15K	F	
150K	H	
1.5K	J	
15M	K	
CHECK	L	

3-24. MEASUREMENT CYCLE START

3-25. To synchronize the measurement cycle to an external source, carry out following steps:

a. Remove jumper connected between J2-a and J2-X. (This disables the measurement cycle recurrence rate circuitry controlled by the front panel SAMPLING RATE potentiometer

b. Connect jumper between J2-a and J2-Y. (This sets measurement cycle to occur on one-shot basis when triggered by an external signal.)

c. Connect external triggering pulse to J2-Z. Pulse amplitude should be greater than +10 volts, and have a rapid rise time.

SECTION IV
THEORY OF OPERATION

4-1. SCOPE OF SECTION

4-2. This section contains a description of the theory of operation of the Model 7100 Integrating Digital Meter. The theory consists of a general discussion of the operating principles of the instrument followed by a detailed discussion of the various sections of the circuitry.

4-3. BASIC OPERATING PRINCIPLES

4-4. Figure 4-1 is a block diagram of the meter and figure 4-2 shows circuit timing. In order to understand how the instrument operates, assume that an unknown dc voltage is applied to the "volts" input terminal. This signal is coupled to the input ranging amplifier, the overall gain of

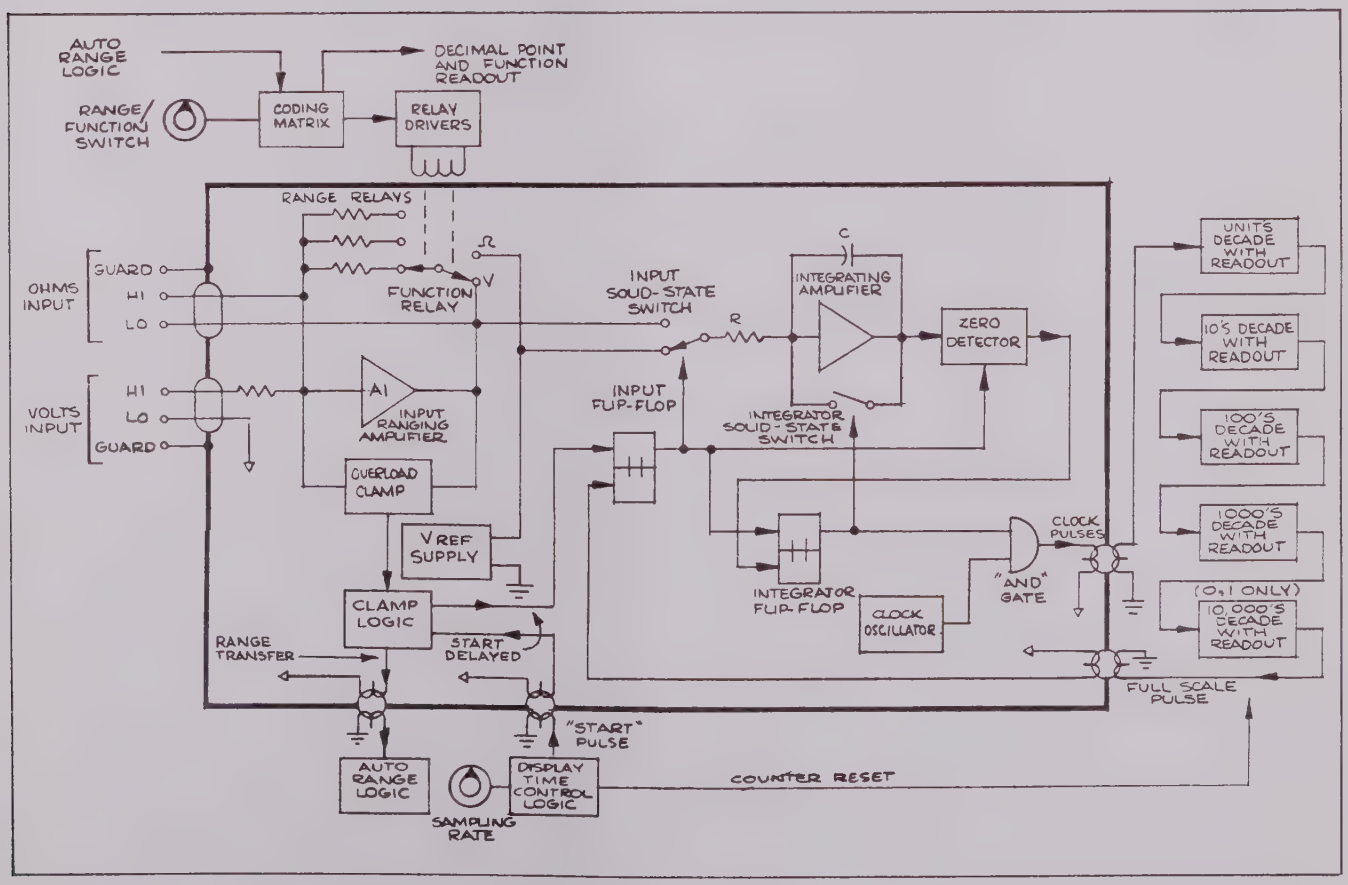


Figure 4-1 Model 7100 Block Diagram

which is set by the value of negative feedback resistor selected by the range switch. The output of the range amplifier is limited to a maximum of 15.9 volts, keeping the circuits that follow from being saturated. Circuit conditions just prior to a measurement cycle are represented by the left-hand side of figure 4-2 . A start pulse is generated by the control logic and is fed to the measuring circuit. (The recurrence rate of the start signal is controlled manually by the front panel "sampling rate" control or by an external program. The rate can be varied from four measurements per second to one every two seconds with the front panel control). The leading edge of the start pulse (time t_1) resets the counter to 10000.

4-5. The trailing edge of the start pulse (time t_2) starts the instrument on a measurement cycle. The signal generated by the trailing edge of the start pulse sets the input flip-flop to cause a) input solid-state switch to connect the output of the ranging amplifier to the input of the integrating circuit and b) zero detector to be disabled. (The integrating circuit consists of the integrating amplifier and feedback capacitor C1). Simultaneously, the output of the input flip-flop sets the integrator flip-flop which a) opens the integrator solid-state switch to unclamp the integrator and b) closes the AND gate, allowing clock pulses to reach the 5-digit counter.

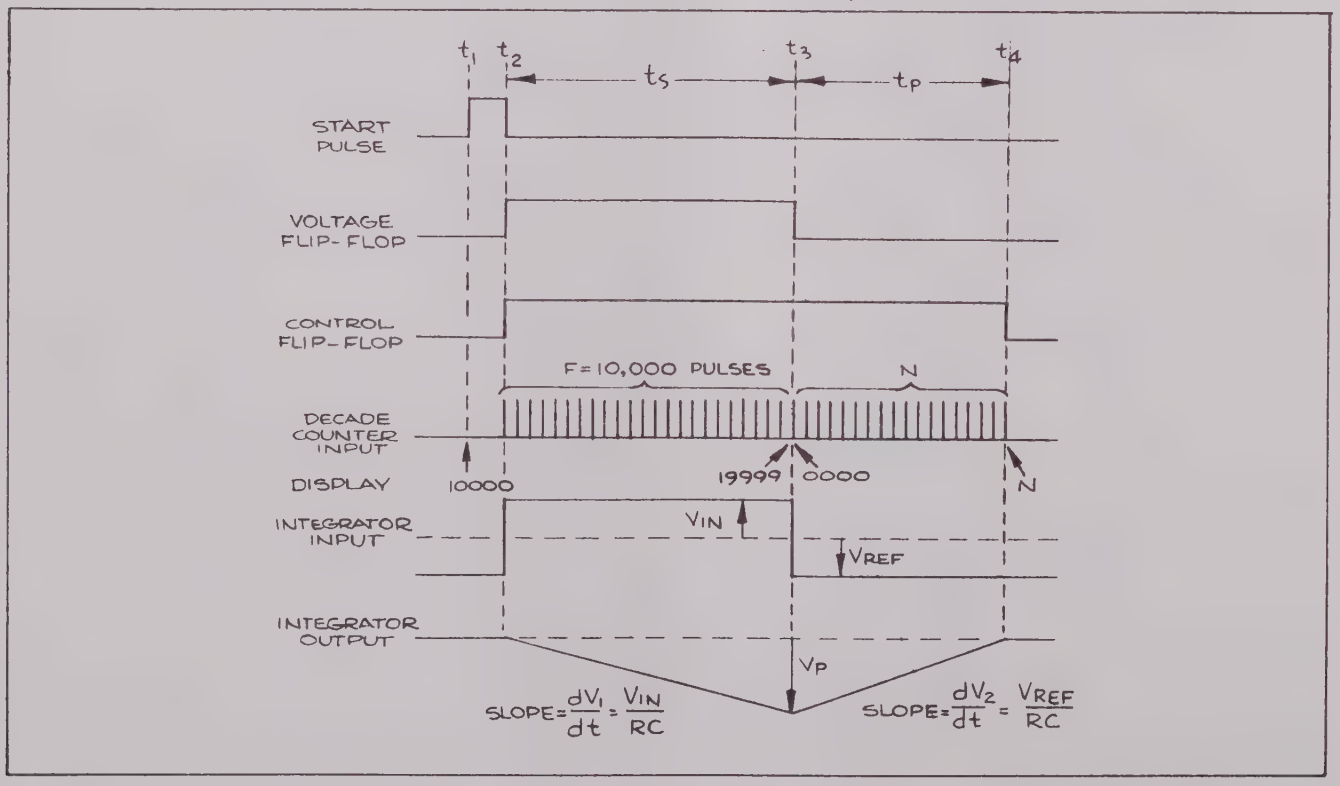


Figure 4-2 Model 7100 Timing Waveforms

4-6. Clock pulses continue to feed through the AND gate and into the counter as the output voltage of the integrator continues to build. The counter can hold 19999 counts (the most significant digit is either 0 or 1 - a short decade) and it has initially been reset to 10000. Therefore, when 9999 pulses have entered the counter, it reads 19999 and is full. The next pulse overflows the counter to 00000 and generates a pulse in the short decade that is fed into the measurement circuitry. This signal, termed the full scale pulse, resets the input flip-flop (time t_3) causing a) input solid-state switch to connect a 10 volt reference to the integrator and b) zero detector to be enabled. (Not shown in figure 4-1 is a polarity sensing circuit that examines the polarity of the integrator at full scale and selects the correct reference polarity to drive the integrator output towards zero).

4-7. The output of the integrator now goes to zero at a constant rate because the reference voltage is derived from a reference source that is stabilized and temperature compensated to a high degree. The time required for the integrator to reach zero is proportional to the integrated input voltage. Pulses counted during this interval (time t_3 to t_4) accumulate in the decade counter, which continues to count, starting from 00000 because of the overflow at time t_3. The zero detector senses when the output of the integrator reaches zero and generates a pulse that resets the integrator flip-flop. The output of the flip-flop a) closes the integrator solid-state switch, ensuring that the output will be at zero at the beginning of the next cycle and b) closes the AND gate, preventing further clock pulses from reaching the counter. The instrument now holds the measured value until the next start pulse. Counter capacity, clock frequency, and range-switch calibration are designed so that the readout is in volts.

4-8. It should be noted that the reference voltage used to drive the integrator to zero is either +10 or -10 volts and the output of the ranging amplifier is allowed to be as high as approximately 15 volts. Thus, the output of the integrator can build up at a faster rate than the reference voltage can drive down. As a result, the output counter is allowed to overflow once during the time the reference voltage is being integrated and thus can indicate a count of 15000 or a 50% over-range of the normal 4-digit 9999 count. If the output of the input ranging amplifier exceeds 15.9 volts, an overload clamp reduces the gain of the amplifier to prevent damage. A panel light is also turned on to inform the operator that the measurement is off scale and that a higher range should be selected.

4-9. Resistance is measured by connecting the unknown resistance in the feedback circuit of the input ranging amplifier. The reference voltage is applied to the input of the amplifier through a voltage divider and the overall gain of the amplifier is then a function of the unknown resistance. Circuit

operation is the same as for voltage measurement and the readout is in ohms.

4-10. Voltage ratios from 0.0000 to 1.5000 can also be measured. One of the two voltages involved in the ratio is applied to the regular "volts" input terminal. The other voltage, applied to the "external reference" input replaces the internal reference during the second half of the measurement cycle. The only restriction is that the voltage serving as the reference must be less than 15 volts to avoid saturating the measuring circuits.

4-11. Examining the measurement circuit in more detail, the output of the integrator during time t_2 to t_3 period is a ramp with a slope which is proportional to the input voltage V_{in}:

$$\frac{dV_1}{dt} = \frac{V_{in}}{R_C}$$

When the decade counter switches from its full state value to 00000 (time t_3), the reference is connected to the integrator and its output returns towards zero with a slope which is proportional to the reference voltage:

$$\frac{dV_2}{dt} = \frac{V_{Ref}}{R_C}$$

At zero, the number of accumulated pulses since t_3 is a measure of the ratio of the input voltage and the reference voltage. This is shown as follows:

The peak voltage of the integrator output:

$$V_p = \frac{dV_1}{dt}(t_3 - t_2) = -\frac{V_{in}}{RC} \quad \frac{F}{f_o}$$

(F is the number of pulses it takes to recycle the counter; eg. 10^n for a n-decade counter).

The time to integrate back to zero:

$$(t_4 - t_3) = V_p \frac{1}{\frac{dV_2}{dt}} = -\frac{V_{IN}}{RC}\frac{F}{f_o}\frac{1}{-\frac{V_{REF}}{RC}} = \frac{V_{IN}}{V_{REF}}\frac{F}{f_o}$$

The number of pulses accumulated during this time:

$$N = (t_4 - t_3) f_o = \frac{V_{in}}{V_{Ref}} F.$$

Thus it can be seen that the conversion accuracy is independent of the oscillator frequency f_o, the integrator capacity C, and the integrator resistor R. F is a digital quantity and therefore has no drift, short or long-term. Only short term stability of R, C and f_o during one measurement cycle is essential for accurate conversion and this is maintained in the instrument.

4-12. ADVANTAGES OF DUAL SLOPE TECHNIQUE

4-13. Conventional integrating type digital voltmeters can be fooled by noisy signals to give inaccurate readings. This is due to the fact that the voltage-to-frequency counter commonly used will respond to an apparent change in polarity caused by the zero-crossings of noise peaks that exceed the signal level. It will count such reverse-polarity

peaks (speeding the count accumulation) instead of leaving them uncounted to offset the high-voltage effect of the input signal. Thus, instead of cancelling out noise which has an average value of zero, the meter will in fact invert the crossover peaks and integrate them as part of the dc input signal. Thus, the integral no longer averages out the dc signal level. In addition, if the measurement interval ends during a crossover period, the polarity indicator will be triggered to indicate the wrong polarity.

4-14. In the new dual slope technique employed in the Model 7100, the integral is not broken down into a summation of pulses but instead is one continuous accumulation of voltage in an integrator circuit that includes a high-gain high-swing amplifier. This amplifier remains fully responsive to incremental values, even at levels well above the working level. Thus, it provides true integration over the measurement time interval, with noise causing only instantaneous changes in the integrator slope which completely cancel out during the measurement period. Also, as polarity is sensed only after the complete integral of the unknown voltage is sensed, there is no possibility of incorrect polarity readout.

4-15. COMMON MODE REJECTION

4-16. A common source of readout error in a typical floating input type digital voltmeter is produced by having two grounds in the system - one at the signal source and the other at the voltmeter. This is known as common-mode pickup (one end of the equivalent hum generator is common to both sides of the input leads). Figure 4-3 shows how this type of error is produced in a typical low level measurement. Current caused by hum pickup develops a spurious input voltage

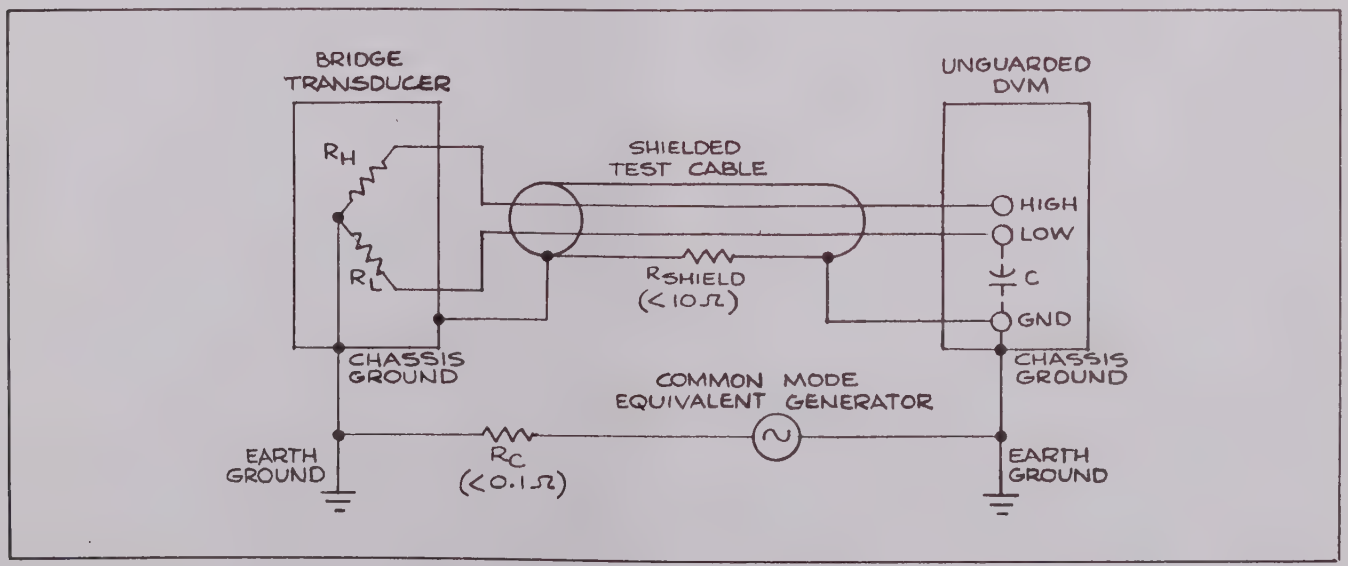


Figure 4-3 Typical DVM Input Circuit

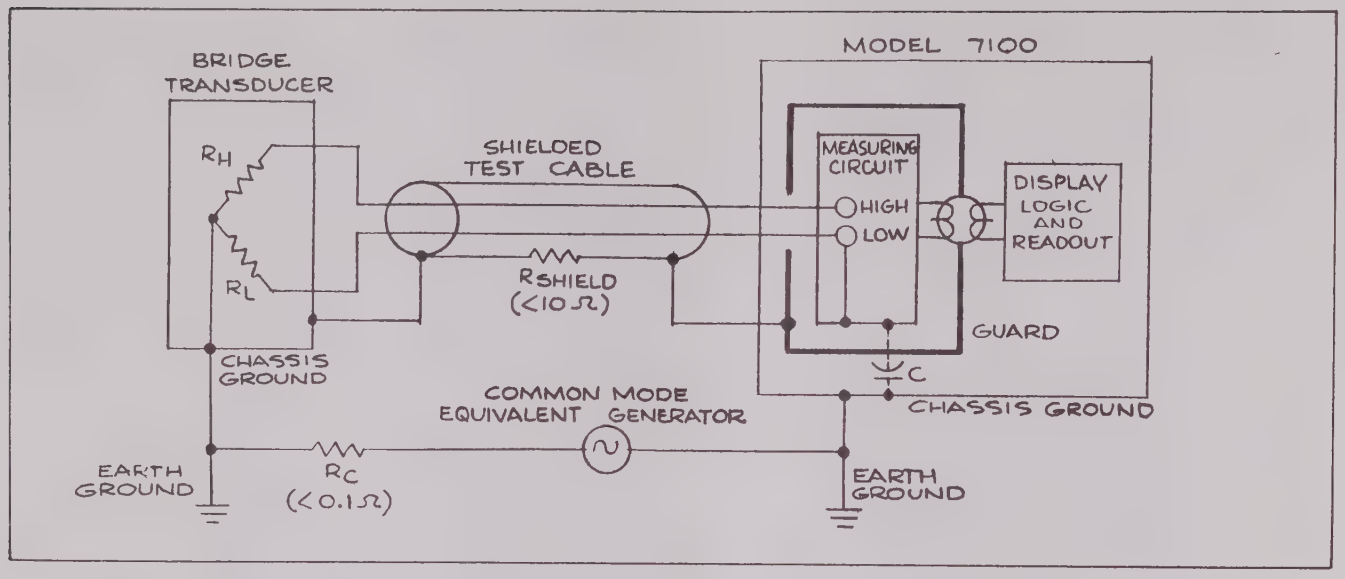


Figure 4-4 Model 7100 Input Circuit

across R_L, and a negligible voltage across R_H (due to high input impedance of the voltmeter). In this type of meter, the value of C (typically 0.1 μf) limits the common-mode rejection to a low level. Also, the shield on the test cable offers little improvement due to low value of R_C.

4-17. A "guarded" measuring circuit concept is used in the Model 7100 to reduce common-mode pickup. See figure 4-4. The floating measuring circuit is enclosed in a metal housing that is "guarded" from the chassis ground of the instrument. All logic signals in and out of the floating section are coupled via pulse transformers and ac input power is obtained from the guarded leads of a specially constructed power transformer. When a measurement is made, the guard is connected to the ground of the voltage source and this in effect breaks the common mode loop. The capacitance between the measuring circuit and chassis ground is now approximately 2.5 pf, and this produces a common mode rejection figure of 140 db at dc and 120 db for all frequencies.

4-18. MEASUREMENT CIRCUIT DESCRIPTION

4-19. The measurement circuit is housed in a "guarded" area consisting of two shielded metal boxes mounted on the right-hand side of the instrument. The larger of the two boxes contains eight plug-in printed circuit boards labelled A1 through A8 on which are mounted the following circuits:

A1 (See figure 5-16 for schematic.)

a) Input solid-state switch controlling input to integrating amplifier.

b) Input flip-flop controlling action of input solid state switch.

c) Reference polarity flip-flop con-

trolling polarity of reference applied to integrating amplifier.

A2 (See figure 5-18 for schematic.)

a) Solid-state differential dc amplifier connected as unity gain inverting amplifier for inversion of positive reference voltage.

b) Solid-state differential dc amplifier connected as integrating amplifier and zero detector.

A3 (See figure 5-20 for schematic.)

a) Internal +10.000 volt reference source.

b) Feedback capacitors for integrating amplifier.

c) Integrator solid-state switch that shorts input and output of integrator between measurement cycles.

d) Integrator flip-flop controlling action of integrator switch.

e) Zero detector logic.

f) Polarity readout pulse driver.

A4 (See Figure 5-22 for schematic.)

a) Synchronized start circuit.

b) Clock and buffer.

c) Clock AND gate and buffer.

d) Zero deadband single-shot.

A5 (See figure 5-23 for schematic.)

a) Solid state 30 volt-dc regulated power supply.

A6 30 volt supply, same as A5.

A7 (See figure 5-25 for schematic.)

a) Input ranging amplifier overload clamp and overload lamp driver.

A8 (See figure 5-26 for schematic.)

a) Input ranging amplifier type A10.

4-20. The second enclosure, designated A16, houses printed-circuit board A17. (See figures 5-9 and 5-31 for schematic.) This board contains reed type relays controlling test mode and range switching and also the input and feedback resistors for input ranging amplifier A8.

4-21. CIRCUIT DESCRIPTION-GENERAL

4-22. Paragraphs 4-23 to 4-66 describe operation of the circuits mounted on boards A1 through A8, board A17, and assembly A16. The order of description follows signal flow within the "guarded" area, rather than by board and assembly designation.

4-23. TRANSISTOR LOGIC

4-24. Most logic functions in the guarded circuitry are performed with saturating NPN transistor inverters with a V_{CC} of 30 volts. When a transistor is turned on, or saturated, the collector is practically a short circuit to the emitter. As the emitter is at -30 volts, the output at the collector will be -30 volts. When the transistor is off, the

collector to emitter path is practically an open circuit and the output at the collector will be approximately ground potential. In the explanation of the circuits, the terms "high" and "low" are used -- these refer to approximately ground and -30 volts respectively. This information may be summarized as follows: a low input to a transistor turns it off and its output is high (approximately ground); a high input to a transistor turns it on and its output is low (-30 volts).

4-25. INPUT CIRCUITRY

4-26. Assembly A16 contains: a number of reed type relays; connections for the ohms, volts, internal reference, and external reference leads; connections for the input ranging amplifier input and output terminals; and the input and feedback resistors for the input ranging amplifier.

4-27. A basic diagram of the circuitry contained in A16 is shown in figure 4-5. See figures 5-9 and 5-31 for full schematics. The reed relays are activated by diode matrix logic located outside the "guarded" area on plug-in board A10. The function/range switch sets the matrix input and the output activates coils that pull in the reeds to set up the appropriate input circuit for the test mode and range selected. Other reeds switch clock frequency, integrating amplifier feedback capacitance value, etc. See table 4-1. For example, when the .15 volt position is selected: K1 selects an input resistance of 100 kΩ for input ranging amplifier A8, K6 selects a feedback resistance of 10 MΩ for A8, K8 completes the feedback loop, K12 selects a feedback capacitor value of .54 μf for the integrating amplifier, and K17 con-

Table 4-1 Range Assembly A16 Relay Operation

Function Switch Position		Range Board A16 Relays (X = energised)																
		K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16	K17
VOLTS	.15	X					X		X				X					X
	1.5		X				X		X					X	X			X
	15		X			X			X					X	X			X
	150		X		X				X					X	X			X
	1500		X	X					X					X	X			X
RATIO			X			X			X					X	X		X	
OHMS	15K			X				X		X	X			X	X			X
	150K				X			X		X	X			X	X			X
	1.5M					X		X		X	X			X	X			X
	15M						X	X		X	X			X	X			X
CHECK						X			X			X		X	X			X

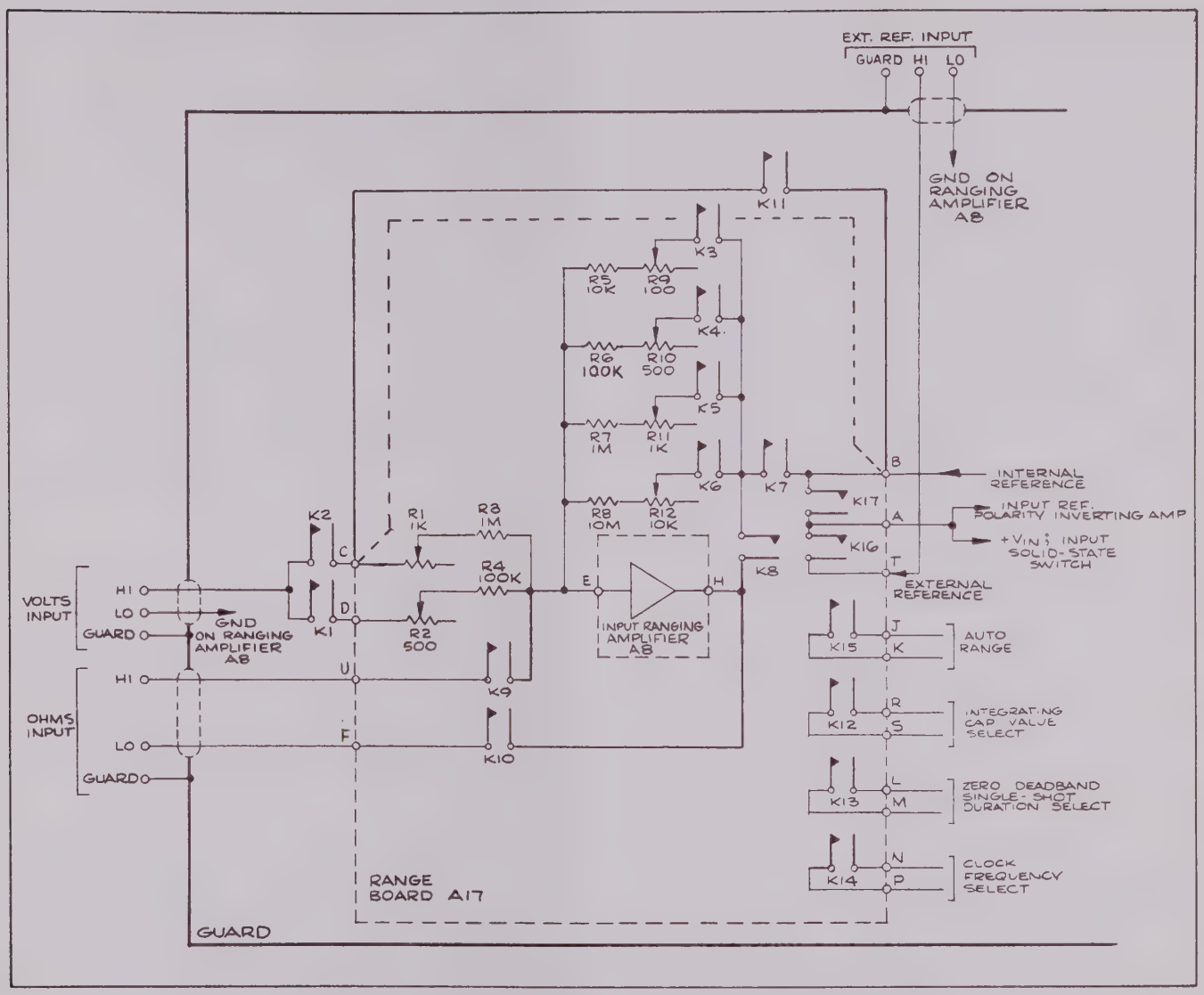


Figure 4-5 Input Circuit

nects the internal reference supply to the input solid-state switch. Relays K13 and K14 are de-energized.

4-28. To isolate the relay coils from the guarded area, the coils are in the form of U-core electromagnets mounted below A16 in such a manner that only the pole pieces protrude into the box.

4-29. INPUT RANGING AMPLIFIER

4-30. The input amplifier is a Fairchild Instrumentation Type A00-10 solid-state photo-resistor chopper-stabilized operational amplifier. See figure 5-26 for full schematic. The internally driven photo-resistor chopper provides an extremely low input drift while eliminating the expense of supplying external drive power. Furthermore, the

elimination of ac power requirements remove a common source of external noise injection. The A-10 further provides a combination of extremely low noise, low drift, large output voltage swing, high input and low output impedances with high open loop gain.

4-31. The basic circuit (see figure 4-6) consists of a differential amplifier which is stabilized by means of a low drift suppressed carrier dc amplifier. In operation, frequencies above 5 cps are coupled directly into differential amplifier "A". Voltages from dc to 5 cps are chopped to ground by photo-resistors R5, R6. The resulting ac is amplified by high gain ac amplifier "B" (carrier amplifier). The amplified signal is demodulated by Q5. After the carrier frequency is filtered out in low-pass filter R26, C14, the original signal is reconstructed and fed into the differential amplifier.

4-32. The dc offset voltage referenced to the summing junction is approximately the offset of the differential amplifier divided through the dc voltage gain of carrier amplifier "B", plus the offset of the input chopper circuit. The chopper drive is a free-running multivibrator operating at a frequency of approximately 120 cps. The maximum output voltage swing is ±25 volts and the maximum current load is 10 ma to ground at ±20 volts.

4-33. The amplifier input and feedback circuitry is housed in range assembly A16 and offset adjustment R3 is mounted on clock board A4. Adjustment instructions for input resistance and offset are detailed in table 5-7.

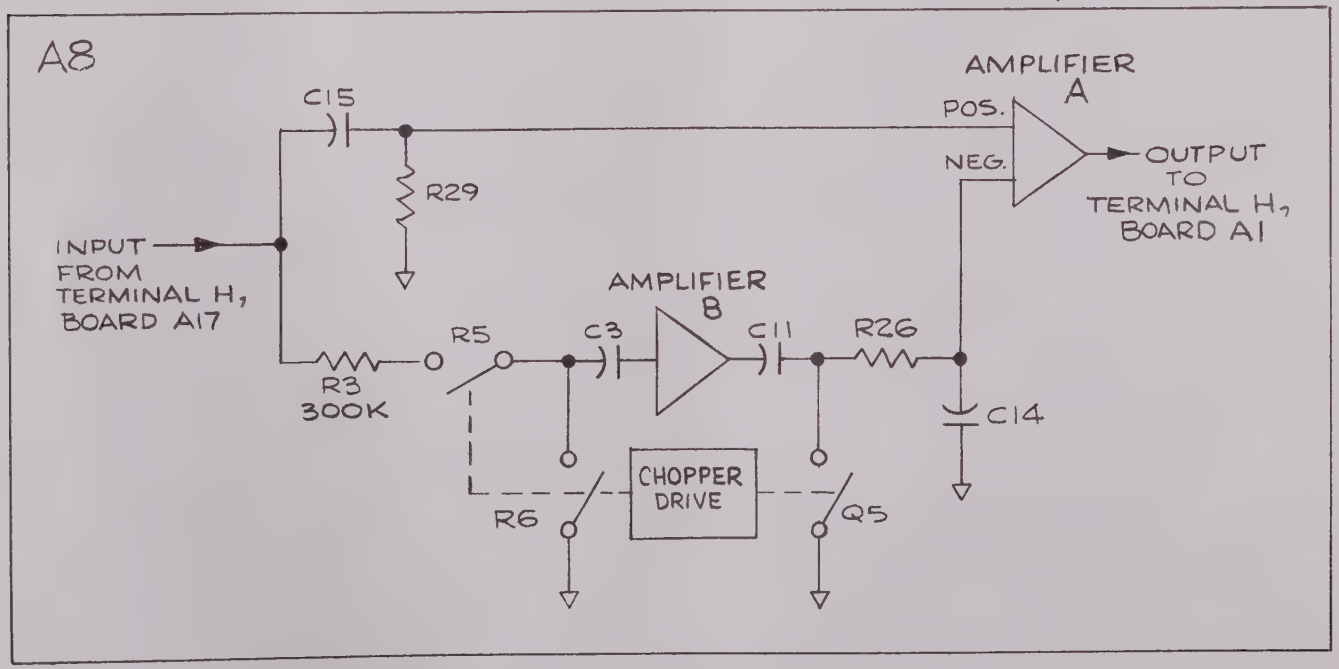


Figure 4-6 Input Ranging Amplifier A8

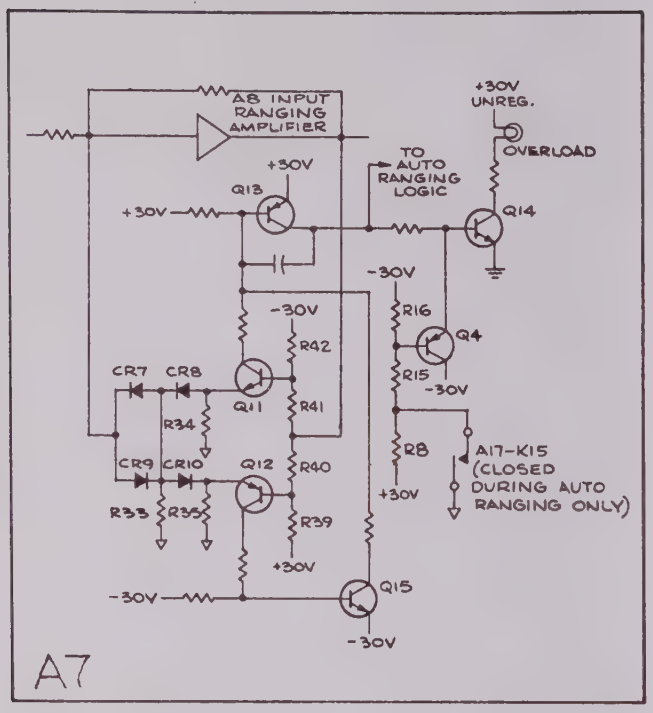


Figure 4-7 Input Ranging Amplifier Clamp

4-34. INPUT RANGING AMPLIFIER CLAMP

4-35. The clamp (see figure 4-7) is connected between the summing junction and output of the amplifier and its purpose is to prevent the amplifier from going into saturation when an excessive input is applied to the meter, thus providing a quick recovery from overload conditions. The clamp is designed to prevent the amplifier output from exceeding + and -15.9 volts. When the amplifier output is zero, Q11 and Q12 are cut off by a DC bias of approximately -15 and +15 volts respectively. As the amplifier output increases, reverse bias is decreased on one transistor and increased on the other. For example, if the amplifier output goes positive to approximately 15 volts, the bias on Q11 becomes zero. Any further increase to 15.9 volts or more, turns on Q11 and the amplifier output is clamped at 15.9 volts via diodes CR7 and CR8. Similarly, a negative output of -15.9 volts is clamped via Q12, and CR9, CR10. Transistors Q15 and Q13 provide drive for overload lamp driver Q14. When Q11 conducts, it provides a current source for Q13 which in turn saturates Q14 and turns on the indicator. (Relay A17-K15 and transistor Q4 disable the readout during automatic ranging). Negative clamp Q12 turns on Q15, Q13 and Q14 to operate the indicator. Diodes CR7, CR8, and CR9 and CR10 together with R33, R34, and R35 are connected as shown to minimize leakage when the clamp is in the off condition. The other components on board A7 are part of the automatic ranging circuit described in appendix E.

4-36. REFERENCE CIRCUIT

4-37. The reference voltage employed in the measurement circuit is derived from two sources: internally when volts, ohms, and check mode of operation is selected; and externally when ratio mode is programed. Figure 4-8 shows the basic circuit. The internal reference is derived from a +10.000 volt source connected by relay K17 to the solid-state input switch. As a reference of opposite polarity is also required, a dc differential amplifier connected as a unity gain operational amplifier is used to invert the source output and supply -10.000 volts to the switch. When volts ratio is selected, K17 is de-energised and instead K16 is closed to supply the positive external reference input to the same points.

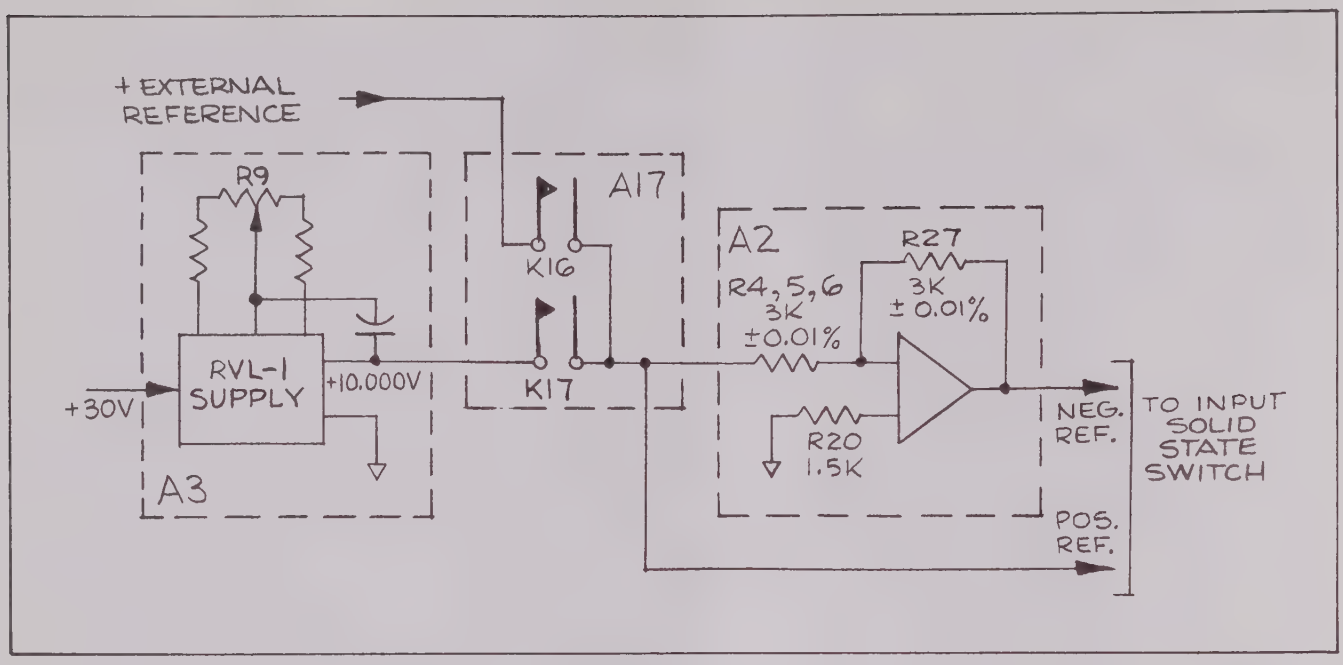


Figure 4-8 Reference Circuit

4-38. The internal reference is obtained from a Fairchild Semiconductor model RVL-1 precision voltage reference. The unit is sealed in an epoxy filled plastic case designed for mounting on a printed circuit board. The output can be set to exactly +10.000 volts within a ±2% limit by externally located potentiometer R9. The input power is +30 volts, supplied by the 30 volt supply on plug-in board A5. Regulation of the reference is ±0.003% or less for 1 volt change in input and stability is ±0.01% per month. The unit contains automatic short-circuit protection circuitry.

4-39. The dc differential amplifier used as an inverter is a solid-state unit. See figure 5-18 for full schematic. The differential input stage consists of Q2 and Q4, two Fairchild Semiconductor special product devices with matched parameters. Q6 and Q8 are two stages of voltage amplification, and Q11 is an emitter follower. Input and feedback resistance is 3 k ±0.01%.

4-40. INPUT SOLID-STATE SWITCH

4-41. The basic circuit for the input solid-state switch is shown in figure 4-9. The purpose of the switch is to control application of the V_{in} signal (output of ranging amplifier) and reference voltage to the input of the integrating amplifier. During the measurement cycle, V_{in} is applied for 9999 counts and then the input is changed to a V_{Ref} of the correct polarity until zero crossover is detected. The circuit is basically a 3-position, solid-state switch designed for bi-polar operation. In operation, only one of the three constant current gen-

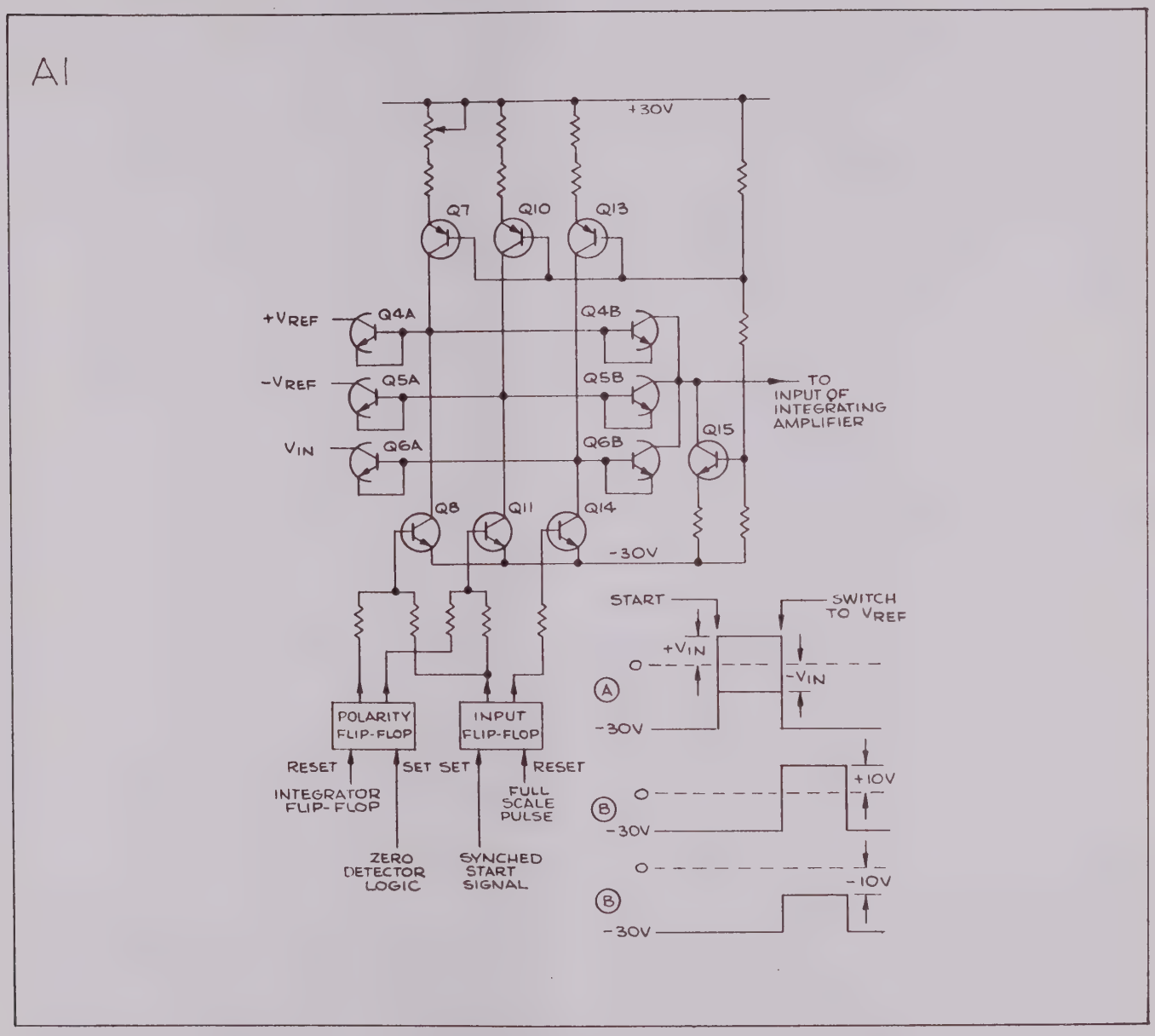


Figure 4-9 Input Solid-State Switch

erators Q7, Q10 and Q13 supplies its current I into the switching diodes since only one of the drive transistors Q8, Q11 and Q14 is off at any given time. Q15 is a constant current generator and absorbs half of the current I. The remaining half is absorbed by the voltage source V_{in}, $+V_{Ref}$ or $-V_{Ref}$, all of which are low impedance sources. The voltage drops cancel and a temperature coefficient of ±10 μv/°C results.

4-42. The operation of the driver transistors is determined by the input and polarity flip-flops described in separate paragraphs. Q8 and Q11 controlling the V_{Ref} inputs are 2-input AND gates. During the

V_{in} period when the input to Q14 is low, the opposite side of the input flip-flop holds a high input on Q8 and Q11. This opens the V_{Ref} input lines. When the input flip-flop is reset by the full scale pulse, the V_{in} lines is opened and the inhibit is removed from Q8 and Q11. The V_{Ref} line closed is now determined by the state of the polarity flip-flop.

4-43. SYNCHRONIZED START CIRCUIT

4-44. A simplified schematic of the synchronized start circuit is shown in figure 4-10. The purpose of the circuit is to synchronize the measurement cycle start pulse generated by the sampling rate multivibrator on board A11 with the clock frequency to produce a start signal that is used to start the measurement cycle. The circuit operates as follows: negative going clock pulses are applied continuously to the base of Q6 and start pulses are coupled to the base of Q3. (The start pulses are delayed or undelayed according to whether or not auto ranging is in operation. See appendix E). In the absence of a start signal Q3 is off, Q4 is on, and the collector of Q6 is held low. When a start pulse occurs, Q3 turns Q4 off and inverted clock pulses appear at the collector of Q6. For all ranges except the .15 volt position, approximately six clock pulses will be passed before the 10 microsecond input pulse ends; for .15 volt operation at the lower clock rate, a single pulse will appear. In both cases the measurement circuitry is triggered by the low going position of the first clock pulse to appear at the output of Q6.

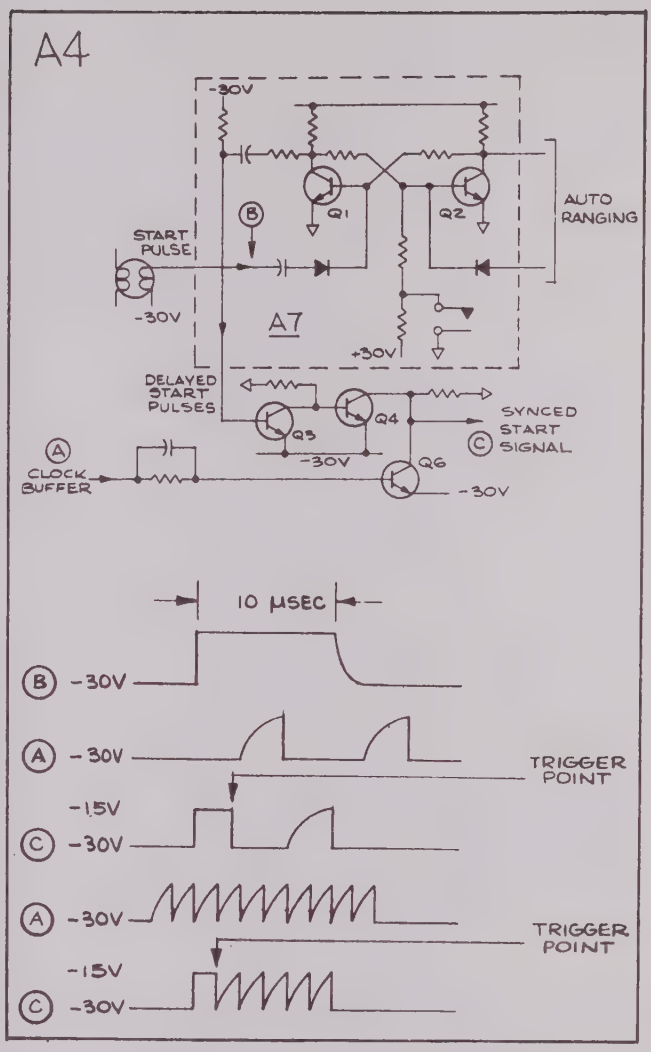


Figure 4-10 Synchronized Start Circuit

4-45. CLOCK

4-46. A simplified schematic of the clock circuit is shown in figure 4-11. Transistors Q2 and Q5 are connected as a free-running astable multivibrator and the output at the collector of Q5 drives buffer Q7. Two clock frequencies are generated: 600 kcs for all test ranges except .15 volts, and 120 kcs for

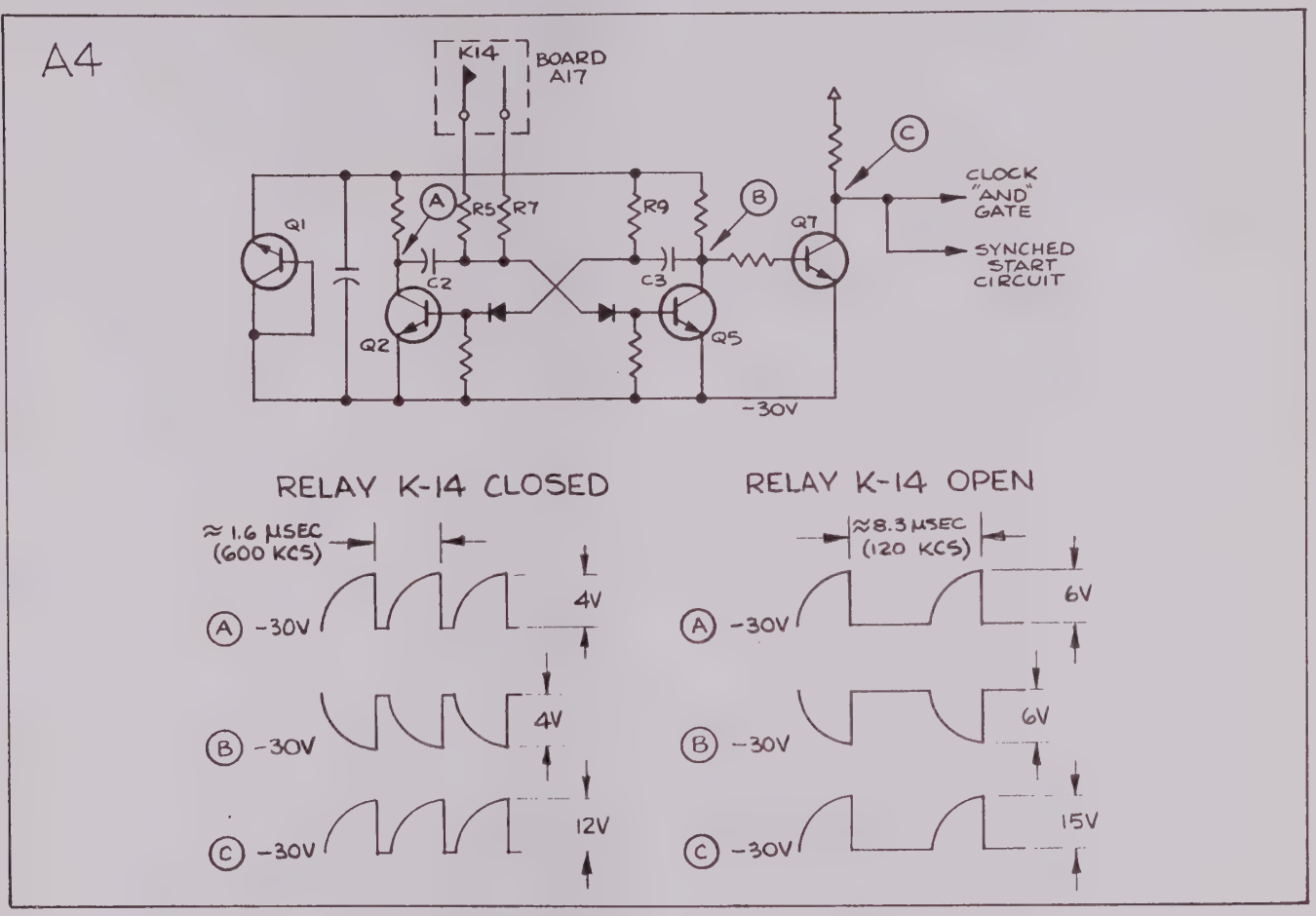


Figure 4-11 Clock

the .15 volt range. The frequencies are established by the RC time constants of C2, R5, and R7 for Q5 and C3, R9, for Q2. Relay K14 is energised to connect R5 and R7 in parallel for all ranges except the .15 volt position. The clock output is coupled to the clock AND gate and the synced start circuit. Transistor Q1 is connected as a 10 volt zener to set the V_{CC} of Q2 and Q5 at approximately 20 volts.

4-47. CLOCK GATE AND DRIVER

4-48. A simplified schematic of the clock gate and driver is shown in figure 4-12. The circuit controls the clock pulses passed to the readout counter. Transistor Q9 is a 3-input inverting AND gate with a V_{CC} supply of 30 volts. All inputs must be low (-30 v) to open the gate. The three inputs are: clock pulses, the output of the integrator flip-flop, and the output of the zero deadband single-shot. (The function of these circuits is described in separate paragraphs). In operation, the output at the collector of Q9 is observed as a train of clock pulses beginning at the start of the measurement cycle, and ending when zero crossover is

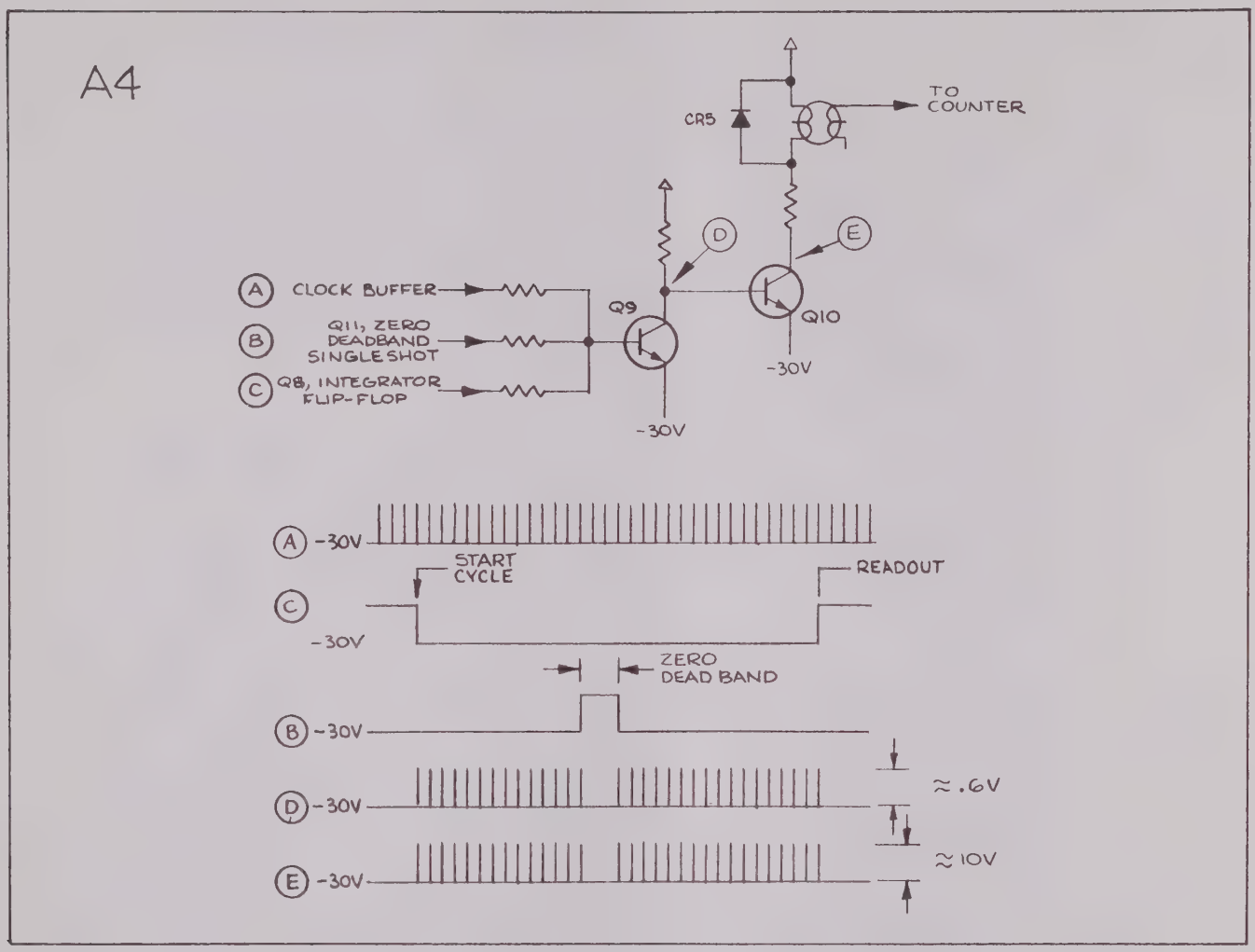


Figure 4-12 Clock Gate and Driver

detected. The gap (approximately 11 counts) near the middle of the train is the zero dead band area. Transistor Q10 is the driver for the pulse transformer coupling the clock pulses to the readout counter. Diode CR5 across the coil is a spike suppressor.

4-49. INPUT FLIP-FLOP

4-50. The basic circuit for the input flip-flop is shown in figure 4-13. The circuit performs the following functions: controls the input solid-state switch so that during the first half of the measurement cycle, V_{in} is passed to the integrating amplifier; inhibits the V_{Ref} input sections of the switch during the same period; and sets the integrator flip-flop. Operation of the circuit is as follows: The synced start signal applied to the base of Q9 sets the flip-flop so that Q12 is on and Q9 is off. At this time the low output of Q12 opens the V_{in} line of the input switch and the high output of Q9 closes the $+V_{Ref}$ and $-V_{Ref}$ lines.

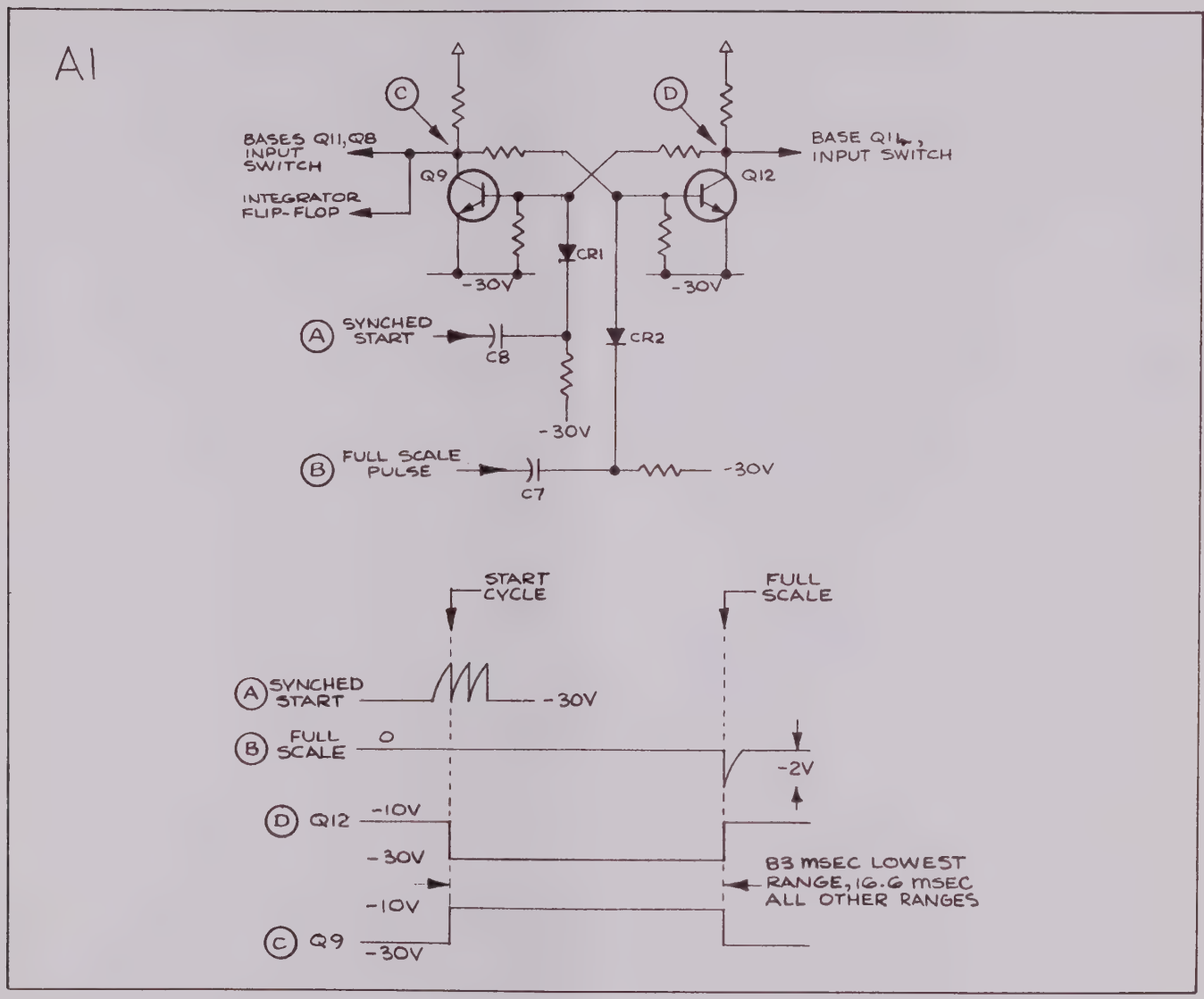


Figure 4-13 Input Flip-Flop

The high going signal at the collector of Q12 sets the integrator flip-flop coincident with the opening of the V_{in} line. The circuit remains in this position until the low going full scale pulse is applied to the base of Q12. This resets the flip-flop so that Q12 is off and Q9 is on. The V_{in} line is now opened and the inhibit is removed from the reference lines. (The polarity of the reference is selected by the reference polarity flip-flop). The circuit remains in this condition until the next synced start signal is generated. Thus, during the time between measurement cycles, the V_{Ref} lines of the input switch are closed (actually only the $-V_{Ref}$) and a reference voltage is applied to the integrator input. However, the solid state switch across the amplifier is closed during this time so that when the cycle begins, the input is at zero.

4-51. INTEGRATOR FLIP-FLOP

4-52. The basic circuit for the integrator flip-flop is shown in figure 4-14. This circuit: Supplies drive to the solid-state switch across the summing junction and output of the integrating amplifier, opening it during the measurement cycle; opens the clock AND gate during the same period; and resets the polarity flip-flop at the end of the measurement period. Operation is as follows: At the start of the measurement cycle, the output of Q9 in the input flip-flop goes high and sets the flip-flop. Q5 is off, Q8 is on and the first two circuit conditions described above are enabled. The circuit remains in this state until the zero detector senses when the integrator output reaches zero. At this time, the high going output from the zero detector logic applied to Q5 resets the flip-flop. Q5 is now on, Q8 is off and the polarity flip-flop is reset. The circuit remains in this state until the next cycle begins.

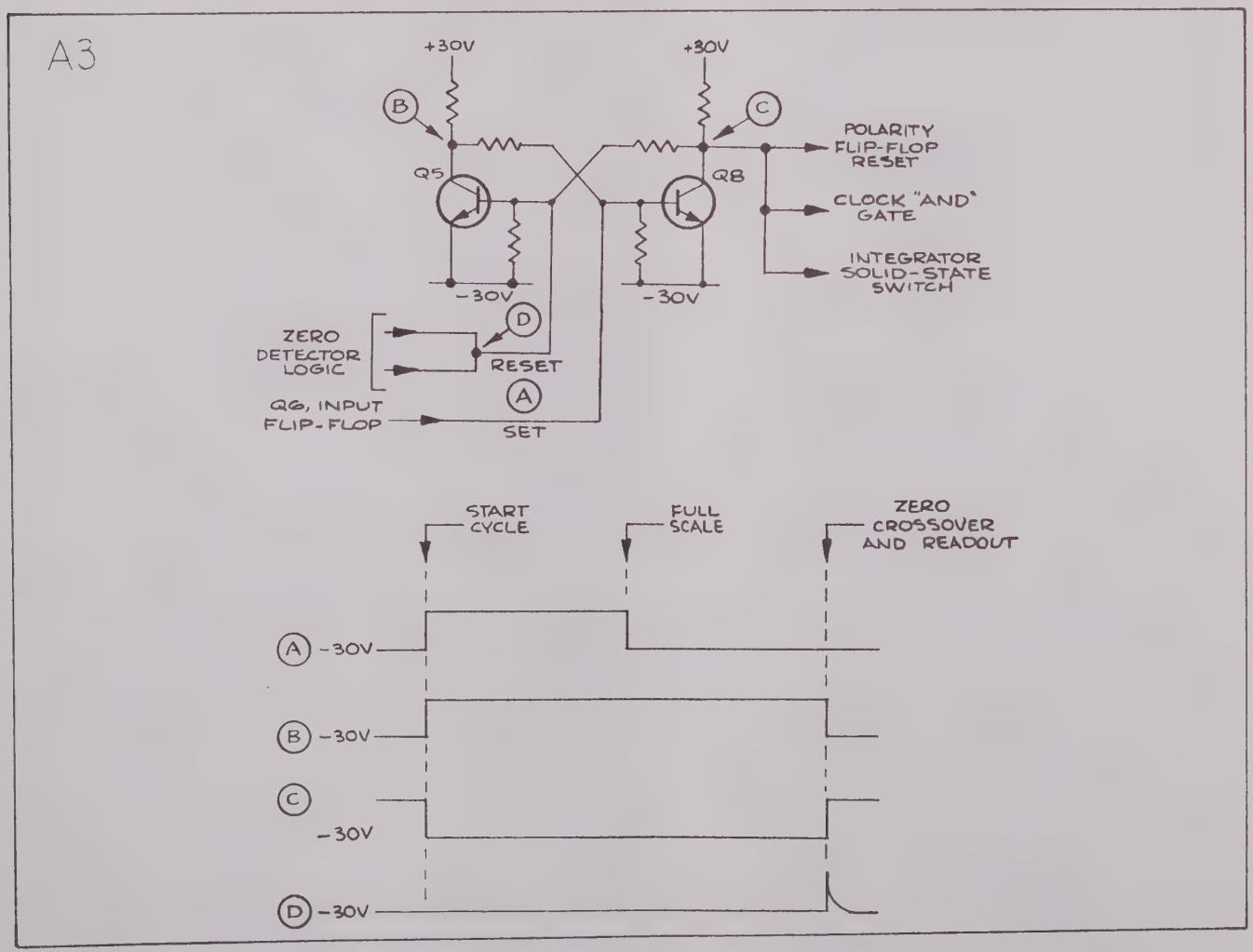


Figure 4-14 Integrator Flip-Flop

4-53. POLARITY FLIP-FLOP

4-54. The basic circuit for the polarity flip-flop is shown in figure 4-15. The purpose of the circuit is to supply drive to the solid-state input switch such that a reference voltage of the correct polarity is applied to the integrating amplifier. The reference polarity required is: negative (-) for a negative input voltage, and positive (+) for a positive input. The flip-flop also controls action of the zero detector logic. The circuit operates as follows: At the end of the measurement cycle, the integrator flip-flop resets the polarity flip-flop so that at the start of the measurement cycle Q1 is off and Q3 is on. However, during the time from cycle start to full scale, the high output from the input flip-flop is applied to both sides of the polarity flip-flop causing saturation of both sides. This effectively inhibits the flip-flop during the first half

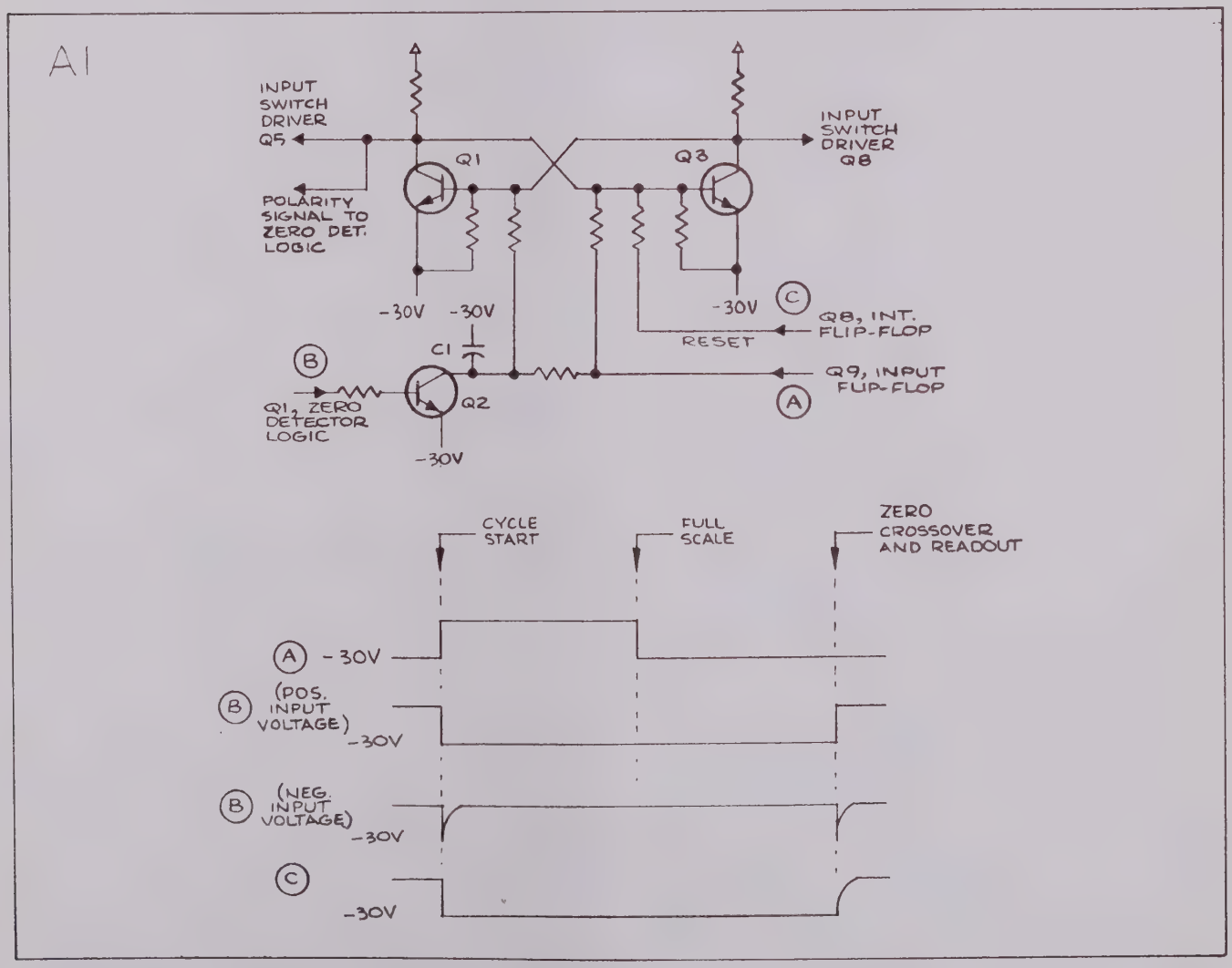


Figure 4-15 Polarity Flip-Flop

of the cycle, preventing spurious signals from the zero detector from being applied to the flip-flop. At full scale the flip-flop reverts back to the reset state previously described. The action of the flip-flop is now determined by the comparator signal from the zero detector logic circuit. This signal is low for a positive input voltage and high for a negative input. In the flip-flop reset state, Q1 is off and Q3 is on. Q1 is coupled to input switch driver Q8 ($+V_{Ref}$) and turns it on; Q3 is coupled to input switch driver Q11 ($-V_{Ref}$) and turns it off. The driver turned off closes the switch inhibit line therefore in the reset condition $-V_{Ref}$ is coupled to integration amplifier. A

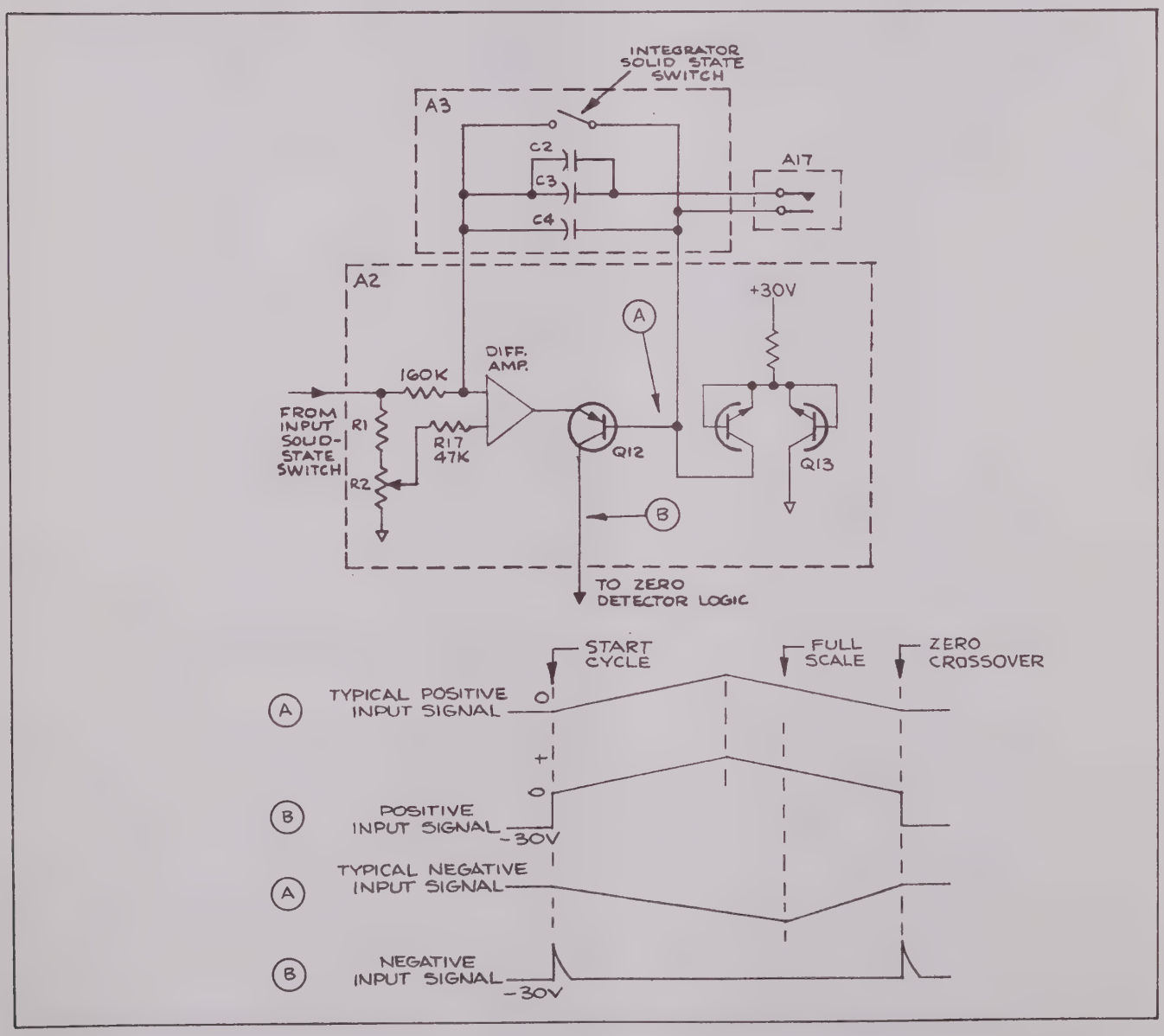


Figure 4-16 Integrating Amplifier and Zero Detector

high signal from the comparator (negative input voltage) coupled via buffer Q2 to the flip-flop does not change its state therefore the correct reference polarity for a negative input is automatically selected. A low signal from the comparator (positive input voltage) on the other hand sets the flip-flop) reversing the inputs to input switch drivers Q8 and Q11. This opens the $-V_{Ref}$ line and switches $+V_{Ref}$ to the integration amplifier. The circuit remains in this condition until the end of the measurement cycle when the integrator flip-flop resets the flip-flop. The V_{CC} supply for Q2 is obtained from the input flip-flop signal and the circuit is arranged so that the transistor is operative for only a short period following full scale. This prevents spurious signals from being applied to the flip-flop and causing incorrect polarity selection.

4-55. INTEGRATING AMPLIFIER AND ZERO DETECTOR

4-56. The basic circuit for the integrating amplifier and zero detector is shown in figure 4-16. The amplifier is a dc differential unit of the same basic type as that used for the reference voltage inverter. See figure 5-16 for full schematic. The feedback capacitors are mounted on plug-in board A3 and are selected by Relay K17, activated in accordance with the readout range selected. See table 4-1. The zero detector consists of Q12, CR3, and CR4, the collector of Q12 being coupled to the input of the zero detector logic circuit. A solid-state switch, connected across the summing junction and output of the amplifier is closed between measurement cycles. An offset adjustment, derived from the signal input is used to compensate for the amplifier response characteristic described in paragraph 4-64.

4-57. INTEGRATOR SOLID-STATE SWITCH

4-58. The basic circuit for the integrator solid-state switch is shown in figure 4-17. The switch consists of Q6 and Q7 operated in an inverse V_{CE} Sat mode to provide an extremely low offset voltage when the switch is in the on condition and a low leakage when it is off. The switch is driven by the high going signal at the collector of Q8 in the integrator flip-flop. The switch is opened when the measurement cycle is started and closed when it ends. An additional input

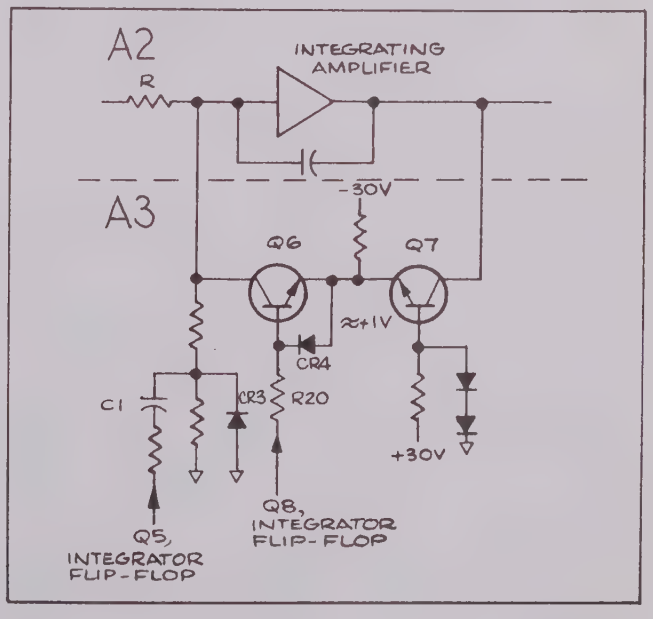


Figure 4-17 Integrator Solid-State Switch

from Q5 in the integrator flip-flop is to counteract the C_{ob} characteristic of Q6.

4-59. ZERO DETECTOR LOGIC

4-60. The basic circuit for the zero detector logic is shown in figure 4-18. This circuit is required due to the bipolar nature of the zero detector output at zero crossover: for a $+V_{in}$ signal, the output is high and goes low; for a $-V_{in}$ signal the output is low and goes high. The output is used to reset the integrator flip-flop and as it requires a high going signal for this pur-

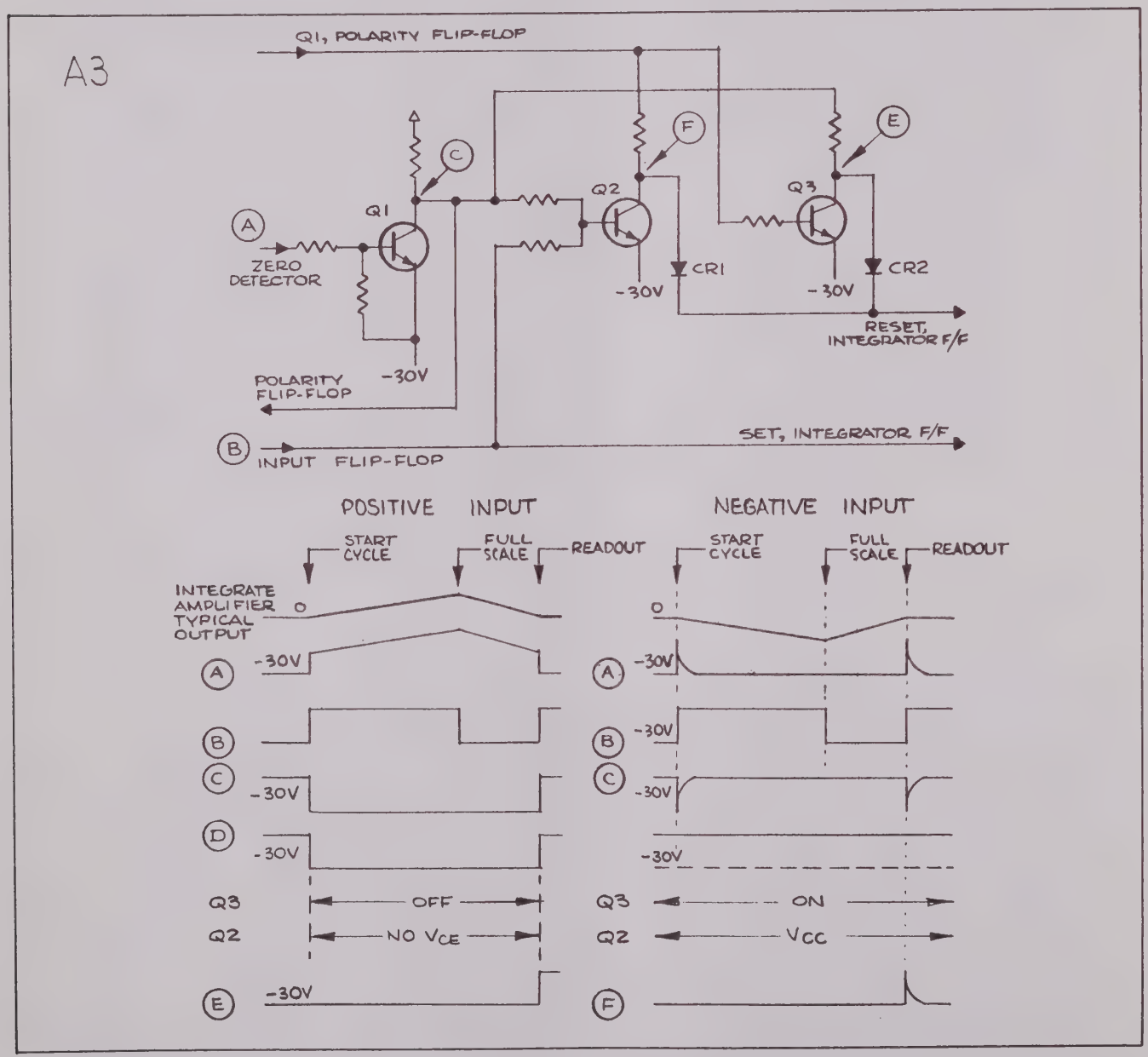


Figure 4-18 Zero Detector Logic

pose, logic is needed to change the zero detector output to the same sense in both cases. The circuit consists of inverter Q1, and gates Q2, Q3. The output of zero detector Q12 is coupled to the input of Q1 and the signal at the collector is an inversion of the input signal. Thus at zero crossover, a negative input voltage produces a low signal; a positive input gives a high going signal. The output from the polarity flip-flop sets the V_B and V_{CC} conditions for Q2 and Q3. In the case of a $+V_{in}$, Q3 is off and Q2 has no V_{CC}. Thus, when the output of Q1 goes high this signal is coupled via CR2 to the integrator flip-flop. For a negative input, Q3 is on and Q2 has V_{CC}. Then, when the output of Q1 goes low, the high going signal at the output of Q2 is coupled via CR1 to the integrator flip-flop. To prevent Q2 from producing an output at the beginning of the measurement cycle, the second input to gate Q2 is from the input flip-flop. This signal is high for the first half of the measurement cycle and thus prevents the first low going pulse from producing an output.

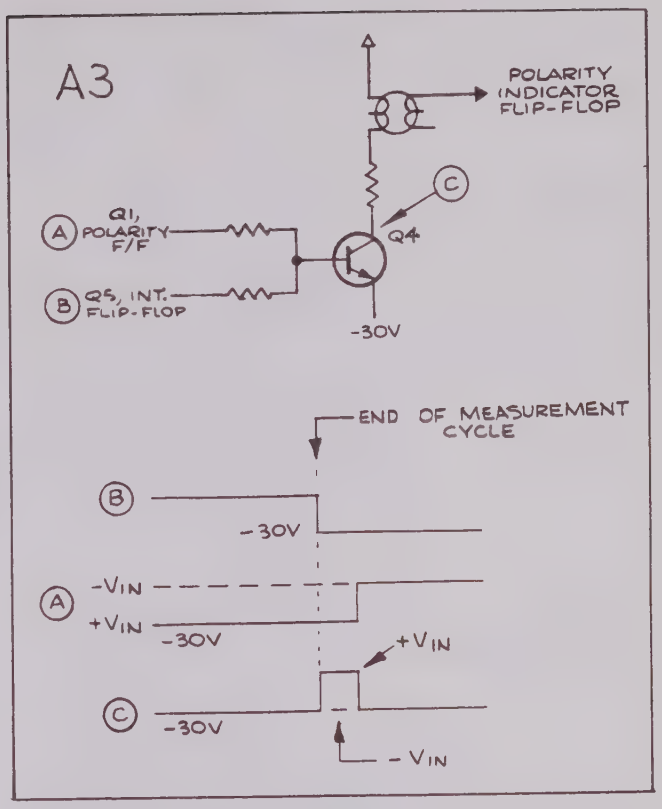


Figure 4-19 Polarity Driver

4-61. POLARITY DRIVER

4-62. The basic circuit for the polarity driver is shown in figure 4-19. Transistor Q4 drives the pulse transformer coupling input voltage polarity data to the polarity readout circuit mounted on plug-in board A11. The circuit operates as follows: Q4 is connected as a 2-input NAND gate. One input is from the polarity flip-flop and the other is from the integrator flip-flop. At the end of the measurement cycle, the integrator line always goes low and simultaneously the polarity line goes low for a positive input signal and stays high for a negative input. Thus, the gate is opened for a positive input and a pulse is passed to the polarity logic. A negative input on the other hand holds the gate closed and there is no output. (Note that although the integrator flip-flop resets the polarity flip-flop, there is sufficient delay between the two circuits to produce the pulse described above).

4-63. ZERO DEADBAND SINGLE-SHOT

4-64. The basic circuit for the zero dead-

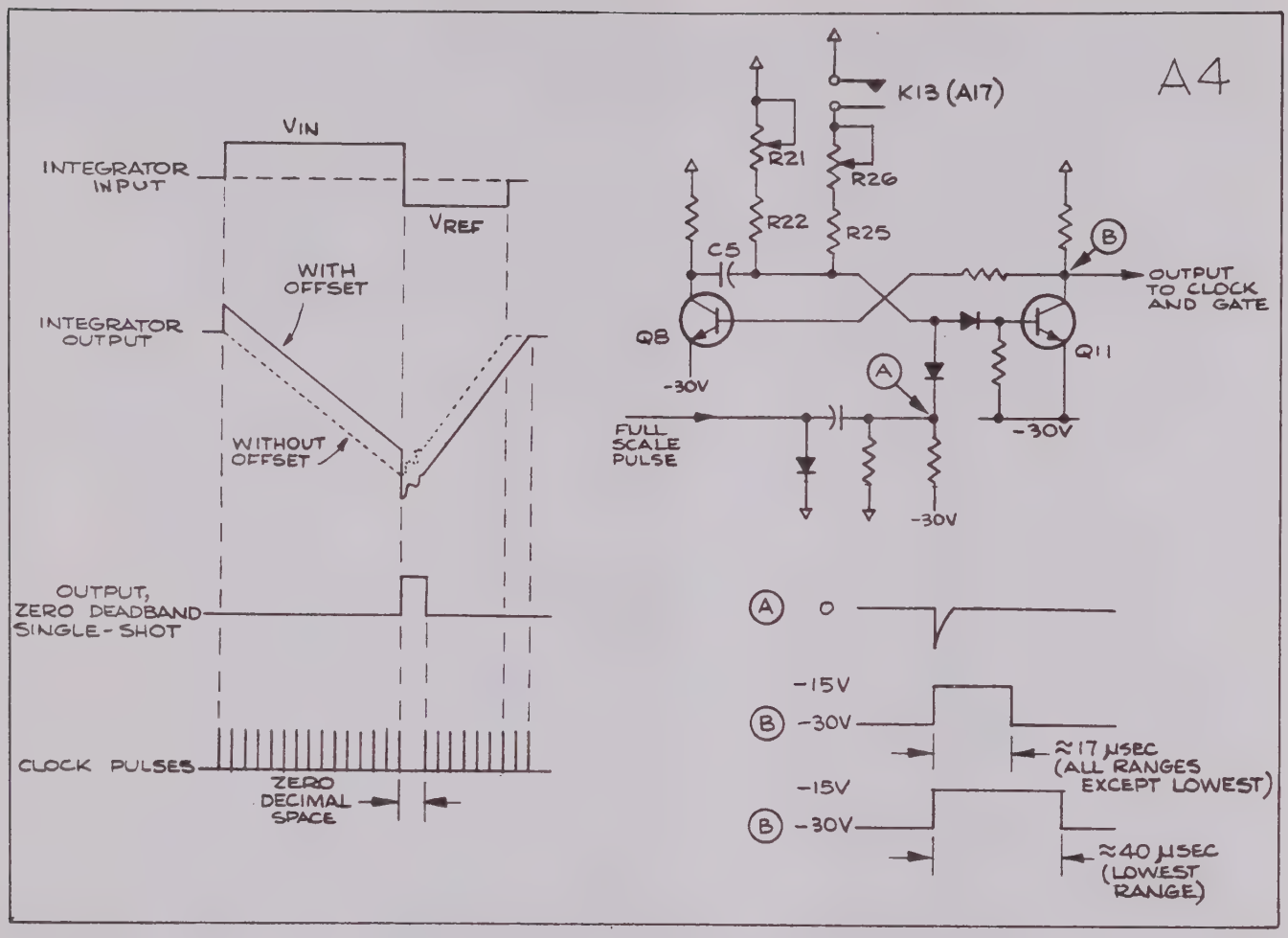


Figure 4-20 Zero Deadband Single-Shot

band single-shot is shown in figure 4-20. The purpose of the single-shot is to compensate for the possible readout error caused by irregularities in the integrating amplifier output waveshape. These irregularities, which occur when the input is switched from V_{in} to V_{Ref} (full scale) are caused by the response characteristics of the amplifier and are liable to produce readout errors, especially at low input signal levels, due to false zero crossover detection. To remedy this, an offset, derived from the input signal, is introduced into the amplifier, moving this portion of the waveform further away from zero. Now, the zero cross-over occurs at a later time in the cycle and to correct for this, the count is inhibited for a certain interval at the beginning of the second half of the measurement cycle. This deadband period is derived from a single-shot triggered by the full scale pulse. The single-shot output is coupled to the clock AND gate and prevents clock pulses from reaching the counter for the duration of its output. In practise this is approximately 11 counts. The adjustment of the single-shot duration

(zero deadband) is fully explained in table 5-7 . As two clock frequencies are used, two pulse durations are required. These are selected by K13 which selects the appropriate RC time constant. See table 4-1.

4-65. +30 V, -30 V POWER SUPPLIES

4-66. The power supplies mounted on boards A5 and A6 are standard Fairchild Corporation type PSR-1 solid-state regulated power supplies. See figure 5-23 for full schematic. This supply is designed to ensure optimum operation of Fairchild Corporation solid-state amplifiers. The ac input voltage is 40 volts RMS, obtained from guarded windings on transformer T1. The output voltage is adjustable to 30 volts and maximum output current is 100 ma. Voltage regulation is ±0.5% maximum for a load change of 0 to 100 ma, and a similar figure for a line change of ±10%. Automatic short circuit protection incorporated in the circuit permits fast recovery to normal operation without long delay or manual resets.

4-67. COUNTER DISPLAY BOARD A10

4-68. Counter display plug-in board A10 is mounted horizontally on the left-hand side of the instrument below power supply plug-in board A11. The board contains the following circuits:

a. Five cascaded decade counters controlling the Amperex numerical readout tubes. (The tubes are mounted on sockets located on the edge of the board). The counters also provide a 5-digit 1224 BCD output for remote readout.

b. Blanking circuit inhibiting instrument and remote readout during measurement cycle.

c. Print command circuit generating a pulse at the end of the measurement cycle suitable for initiating operation of external data logging equipment, etc.

d. Driver coupling full scale pulse to measurement circuitry.

These circuits are described in detail in paragraphs 4-69 through 4-85 below.

4-69. COUNTER

4-70. The counter circuit consists of five decades connected in cascade. The first four are scale-of-ten counters that operate the unit's, 10's, 100's, and 1000's readout indicators; the last decade in the chain is a short decade with an output of 0 and 1 only that drives the 10,000's readout tube. The first decade in the chain is triggered by clock pulses from the measurement circuit and the last decade produces the full scale pulse that is coupled back to the measurement circuit. A basic diagram of one of the scale-of-ten counters is shown in figure 4-21. Four Fairchild Semiconductor type 923 JK integrated circuit flip-flops and a type 914 dual 2-input gate element are connected to form a 122*4 binary counter. The

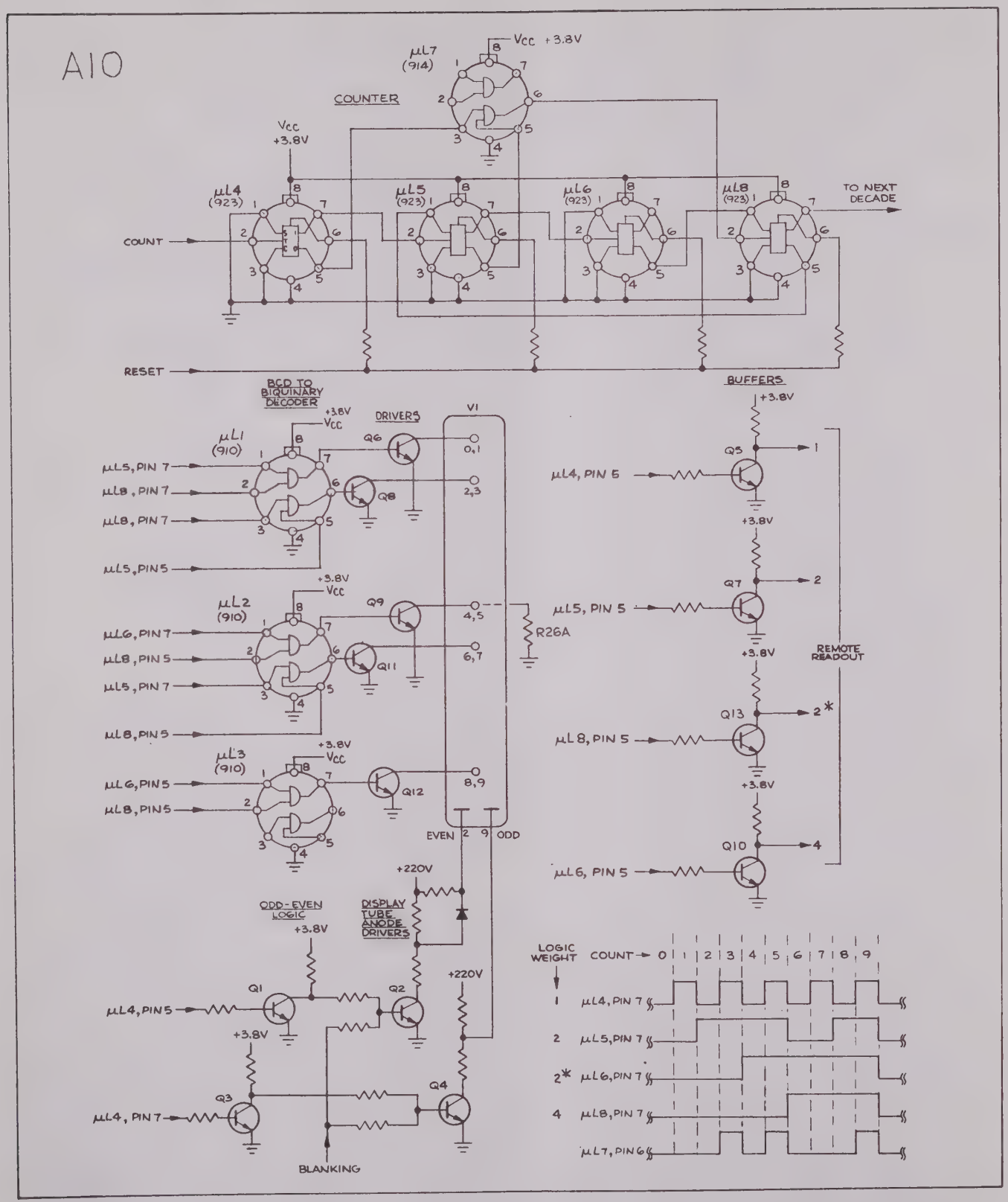


Figure 4-21 Decade Counter

Amperex decimal readout tube requires a biquinary decoded drive and this is obtained from three 910 dual element gates. Drive from the decoder to the tube cathodes is via Q6, Q8, Q9, Q11, and Q12..

4-71. The indicator tube anode drive is derived from the output of the first flip-flop in the counter (μL4). The levels at pins 5 and 7 drive Q1 and Q3 alternately on and off applying high and low inputs to AND gates Q2 and Q4. The second input to the gates is a blanking signal that is high during the measurement cycle and low at all other times. During the measurement cycle this signal saturates Q2 and Q4 with the result that the odd and even anodes are held at a low level and there is no readout. At the end of the cycle, the state of Q1 and Q3 determines which anode is returned to +220 volts. If the count is an even number, flip-flop μL4 pin 5 is high and pin 7 is low. This turns Q2 off and Q4 on, causing +220 volts to be applied to the even anode. An odd count on the other hand turns Q2 on and Q4 off, energising the odd anode.

4-72. The reset signal connected to pin 6

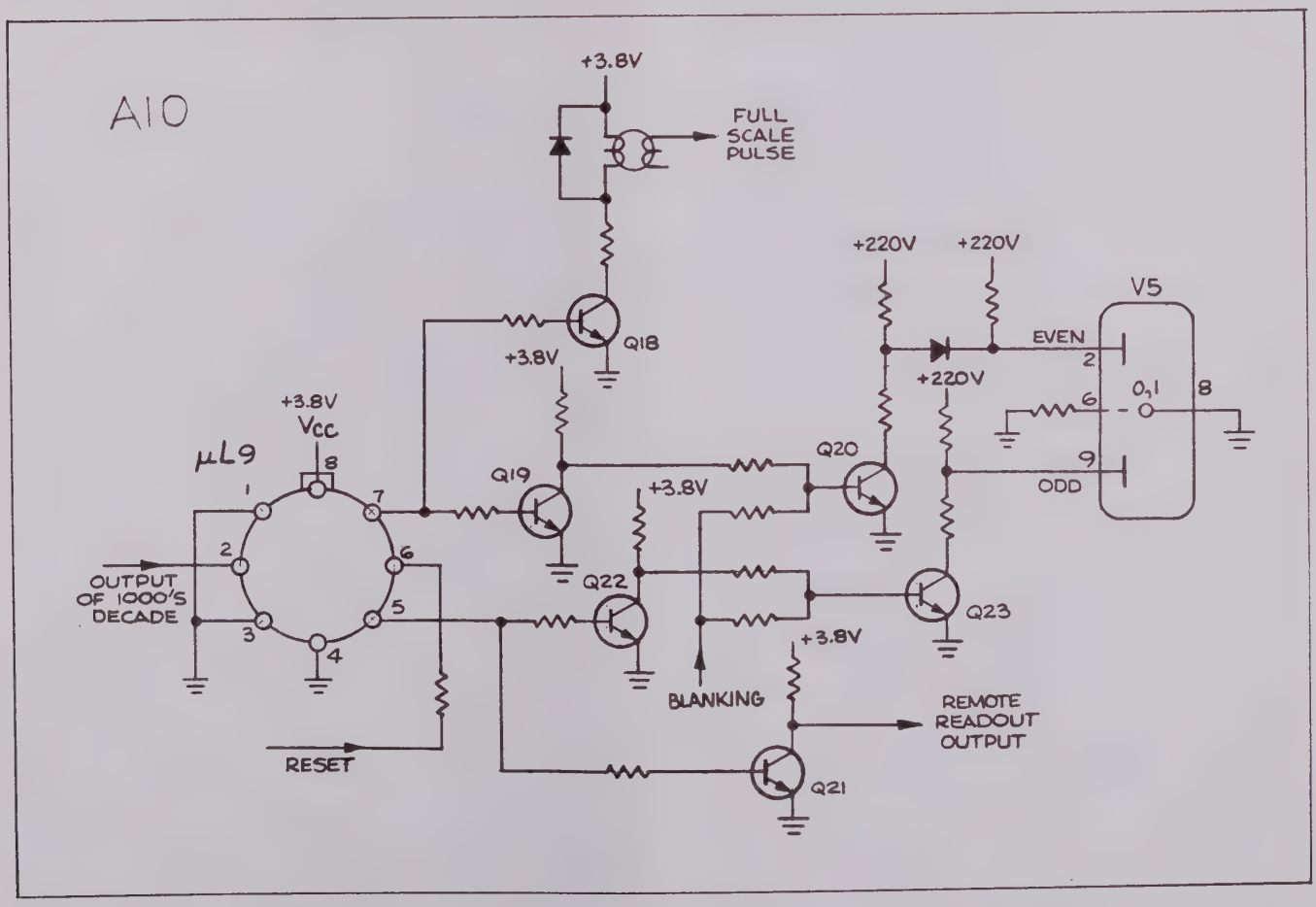


Figure 4-22 Short Decade

of the scale-of-ten decades resets them to "0". The 122*4 BCD readout for remote use is obtained from gates Q5, Q7, Q10, and Q13. Not shown in figure 4-21 is a connection that permits the V_{CC} on the gates to be connected to a +30 volt source. This gives remote output levels of 0 = +0.5 volts, 1 = +30 volts.

4-73. A basic diagram of the short decade is shown in figure 4-22. For this circuit only one JK flip-flop unit is used. In the reset condition output 7 is low and output 5 is high (+3.8 v). This switches Q23 off resulting in an output state at the start of the measurement cycle of "1". The circuit remains in this condition until the complete counter reaches 19999 and the next input count overflows it to 00000. At this time pin 7 of the flip-flop goes high and Q18 produces a full scale pulse.

4-74. AMPEREX DECIMAL READOUT TUBES

4-75. The digital readout employs five Amperex type ZM1030 biquinary numerical indicators, one tube for each decade. A schematic representation of a ZM1030 is shown in figure 4-23. The tube is a cold cathode, gas filled indicator with two anodes and five pairs of cathodes with a transparent screen between odd and even cathodes. The screen divides the tube into two sections: the rear containing the rear or even anode and the cathode numerals 0, 2, 4, 6 and 8; and the front containing the front or odd anode and

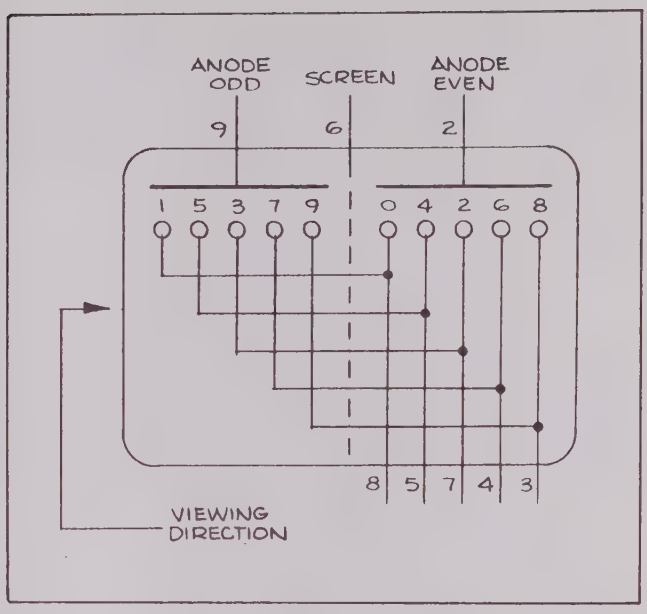


Figure 4-23 Amperex ZM1030 Decimal Readout Tube

cathode numbers 1, 3, 5, 7 and 9. The cathodes are internally connected in pairs 0-1, 2-3, 4-5, etc. By applying a suitable voltage (approximately +240 volts dc) between a cathode pair and the odd anode, the odd number of the pair will be covered with a neon glow. Similarly if 240 volts is applied between a cathode pair and the even anode, the even number of the pair will glow.

4-76. BLANKING CIRCUIT

4-77. A basic diagram of the blanking circuit is shown in figure 4-24. The purpose of the circuit is to generate a signal that inhibits the indicator tubes and remote BCD readout during the period of the measurement cycle. The circuit operates as follows: between measurement cycles, transistor Q16 is on and the output at its collector is

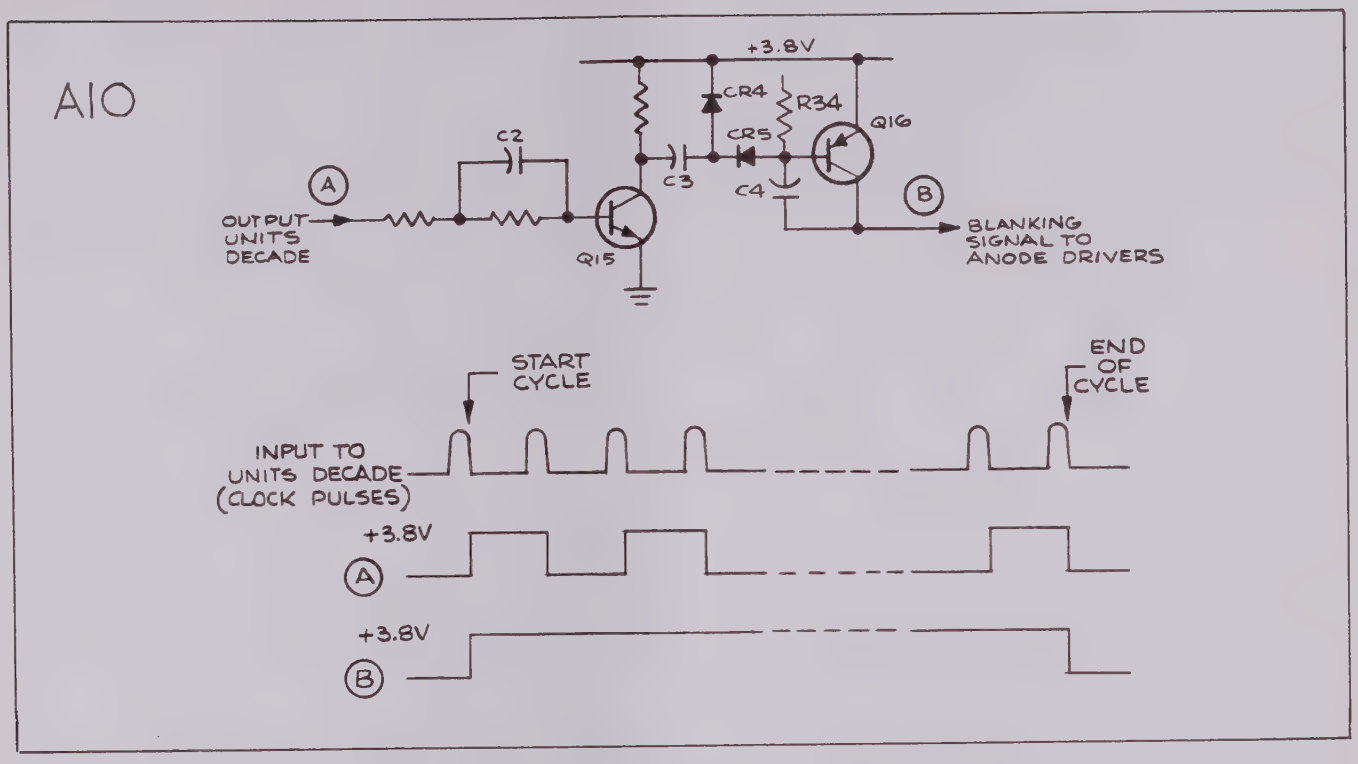


Figure 4-24 Blanking Circuit

low. This allows the readout circuitry to be energised. During a measurement cycle, the output from the first flip-flop in the unit's decade produces a square wave signal at the collector of Q15. This signal is rectified and integrated by CR4, CR5, and C4 and developes a bias that keeps Q16 saturated for the duration of the measurement cycle. The high going signal at the collector of Q16 is the blanking signal used to inhibit the readout.

4-78. PRINT COMMAND

4-79. The basic circuit for the print command generator is shown in figure 4-25. The circuit generates a pulse at the end of the measurement cycle for the purpose of initiating operation of external data logging equipment. The circuit operates as follows: transistor Q17 is normally on due to the biasing action of R37, and the output at the collector is low. The blanking pulse developed by Q16 is differentiated by CR5 and R36 and applied to Q17. The negative spike occuring at the end of the blanking period is passed by CR6 to the base of Q17 and cuts it off momentarily. This produces a high going print command pulse at the collector of Q17.

4-80. 923 JK FLIP-FLOP ELEMENT

4-81. The 923 is a Fairchild Semiconductor Corporation planar epitaxial integrated circuit flip-flop element designed for use in

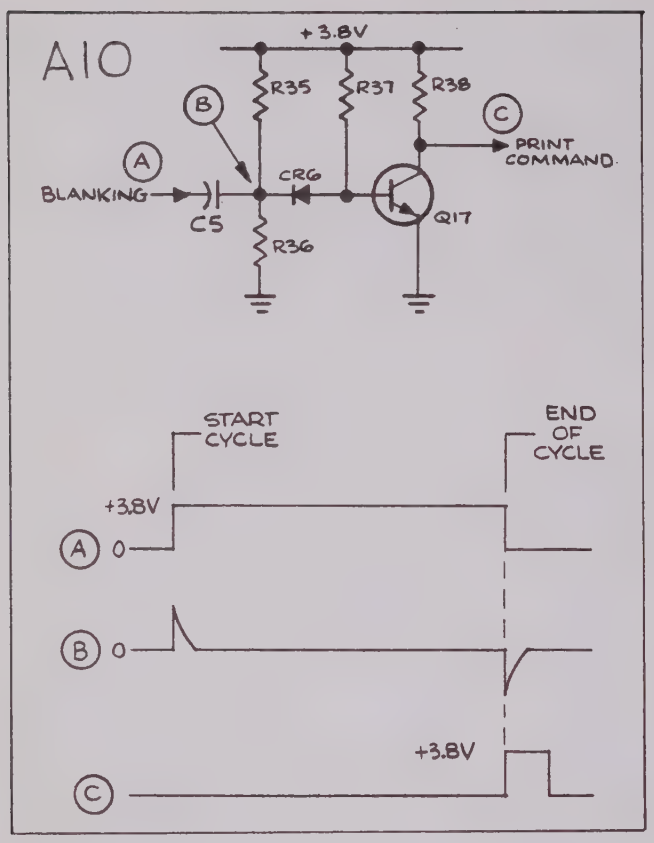


Figure 4-25 Print Command Circuit

counters, shift registers, etc. The JK flip-flop differs from ordinary set/reset flip-flops in that no ambiguous output state can result from simultaneous "one" inputs. In the JK, simultaneous "ones" on both the set and clear inputs cause the output state to toggle (reverse). The flip-flop responds to negative clock transistions. A basic schematic of the element and its circuit symbol are shown in figure 4-26. When a negative going input is applied at pin 2, output conditions are summarised as follows: pins 1 and 3 low - toggle; pins 1 and 3 high - no change; pin 1 low, pin 3 high - 7 low, 5 high; pin 1 high, pin 3 low - pin 7 high, pin 5 low. (high = +3.8 v, low = +0.5 v).

4-82. 910 DUAL GATE ELEMENT

4-83. The 910 is a Fairchild Milliwatt Micrologic integrated circuit dual gate element. A basic schematic of the element and its circuit symbol are shown in figure 4-26.

4-84. 914 GATE ELEMENT

4-85. The 914 is a Fairchild Micrologic integrated circuit two-input gate element. A basic schematic of the element and its circuit symbol are shown in figure 4-26.

4-86. POWER SUPPLY AND LOGIC BOARD A11

4-87. Power supply and logic plug-in board A11 is mounted horizontally in the instrument above plug-in board A10 and contains the following circuits:

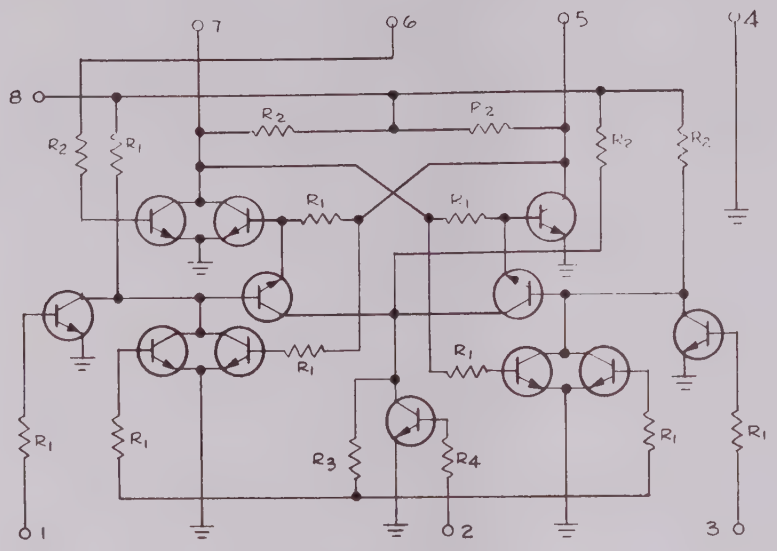
a. +240 volt dc power supply for numerical readout tubes and neon indicators.

b. +30 volt dc supply for reed relay electromagnets.

c. +3.8 volt dc regulated V_{CC} supply for integrated circuits on plug-in board A10.

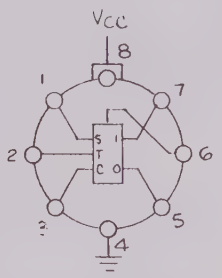
d. Polarity flip-flop and drivers controlling action of (+) and (-) polarity readout indicators.

e. Sampling rate control circuit.

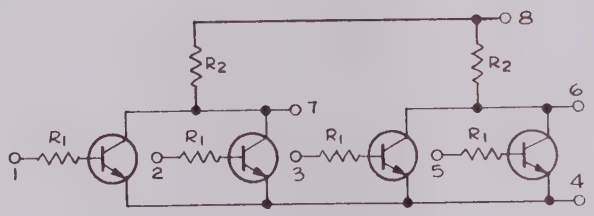


TYPICAL RESISTOR VALUES
$R_1 = 450\Omega$ $R_3 = 510\Omega$
$R_2 = 640\Omega$ $R_4 = 225\Omega$

923 SCHEMATIC

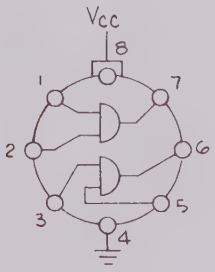


923 SYMBOL

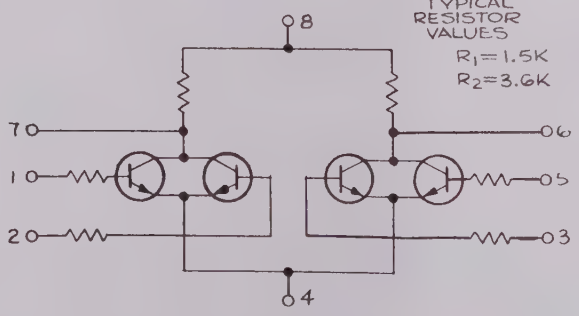


TYPICAL RESISTOR VALUES
$R_1 = 450\Omega$
$R_2 = 640\Omega$

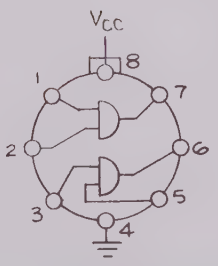
914 SCHEMATIC



914 SYMBOL



910 SCHEMATIC



910 SYMBOL

Figure 4-26 Integrated Circuit Elements

f. Diode matrix controlling action of reed relays in range assembly A16.

g. Resistor matrix controlling decimal point and measurement unit readout.

These circuits are described in paragraph 4-88 through 4-102 below:

4-88. +240 VOLT SUPPLY

4-89. The basic circuit for the 240 volt supply is shown in figure 4-27. The unit

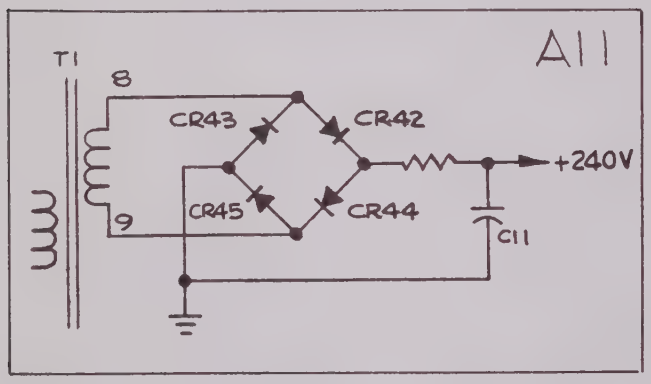


Figure 4-27 +240 Volt Supply

supplies power to the Amperex decimal readout tubes and neon bulbs showing decimal point, polarity, and measurement unit readout. The circuit is a conventional solid-state bridge rectifier with filtered output.

4-90. +30 VOLT SUPPLY

4-91. The basic circuit for the +30 volt supply is shown in figure 4-28. The unit supplies energising voltage for the electromagnets operating the reed relays in range

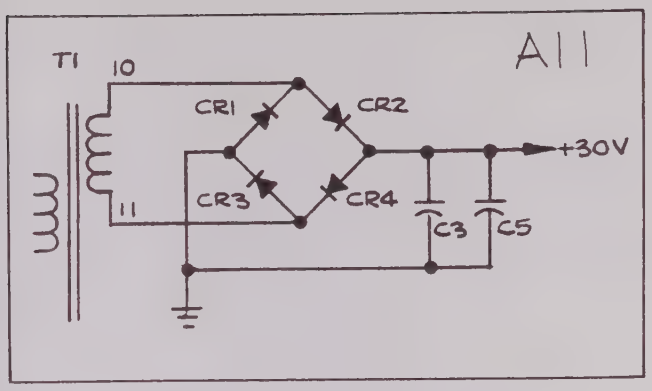


Figure 4-28 +30 Volt Supply

assembly A16 and provides power for the decimal point and measurement unit readout circuit. The supply is a full-wave rectifier circuit with filtered output.

4-92. +3.8 VOLT SUPPLY

4-93. The basic schematic for the +3.8 volt regulated supply is shown in figure 4-29. The output supplies V_{CC} to the integrated circuit elements mounted on plug-in board A10. The supply is a solid-state voltage regulated unit. Transistors Q30 and Q27 operate as a differential amplifier, comparing the output of the supply with a fixed reference developed by CR41, and controlling the action of pass element Q28. In operation, this circuit controls the pass element such that a voltage decrease in the output caused by an increase in the current load lowers the resistance of the pass element and restores the output to its original level. A decrease in load current reverses the action described above and maintains the output voltage at its correct level. Resistor R63 permits the output to be set to +3.8 volts.

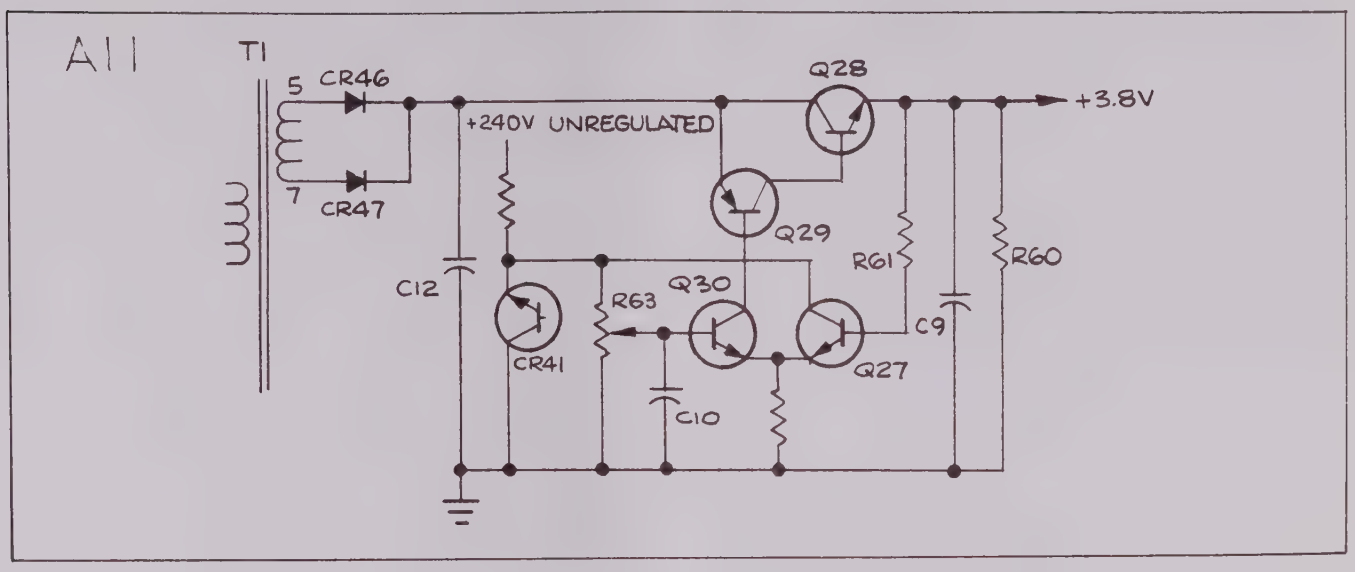


Figure 4-29 +3.8 Volt Regulated Supply

4-94. POLARITY FLIP-FLOP

4-95. The basic circuit for the polarity flip-flop is shown in figure 4-30. The circuit controls operation of the front panel (+) and (-) polarity indicators. The circuit operates as follows: flip-flop Q6, Q8 is reset by the leading edge of the test start

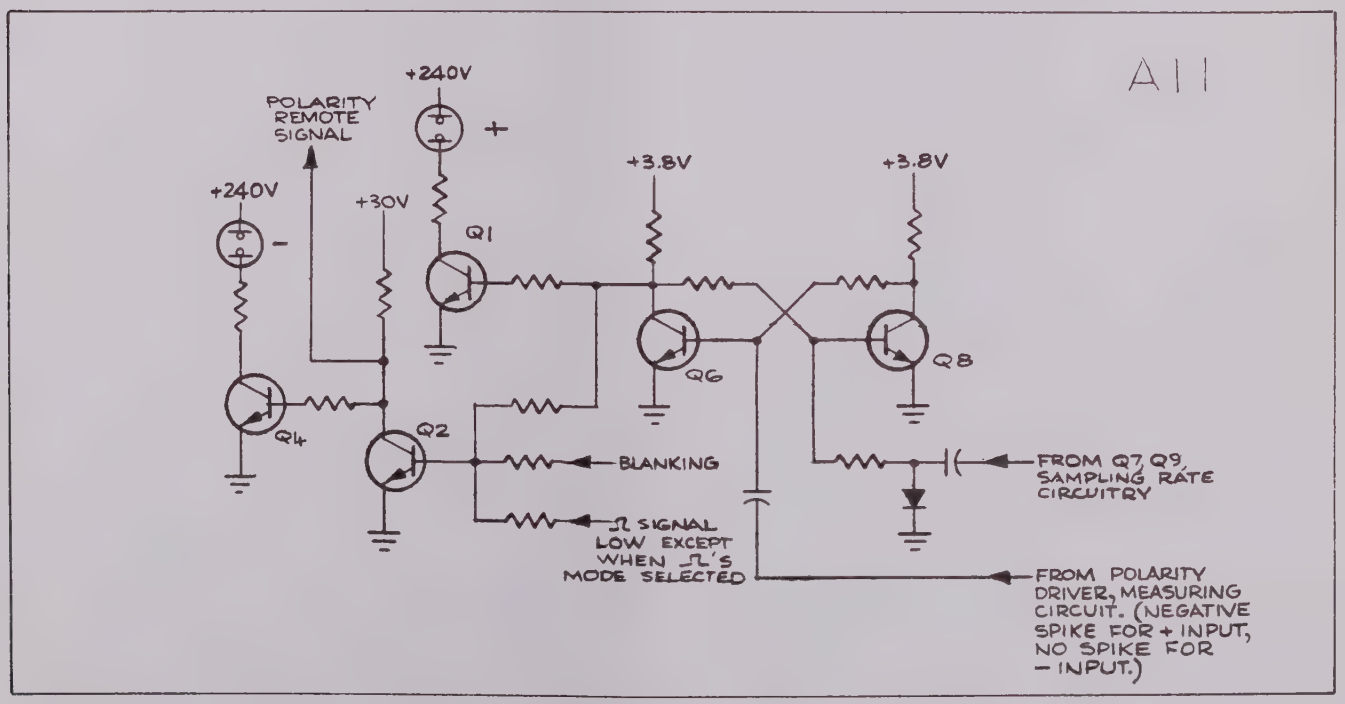


Figure 4-30 Polarity Flip-Flop

pulse generated by the sampling rate circuit. In the reset state Q8 is off and Q6 is on. The signal at the collector drives Q1, the (+) neon driver and Q4, the (-) neon driver via 3-input AND gate Q2. During the measurement cycle, the blanking pulse input to the gate is high and goes low at the end of the cycle. This inhibits the readout of both indicators. (The third input is low during all voltage and ratio tests).

4-96. At the end of the cycle, the flip-flop determines which indicator is energised. If the input voltage is negative, there is no further circuit action after reset and the (-) neon is energised. However, if the input signal is positive the polarity driver circuit (see paragraph 4-71) produces a negative spike at full scale that sets Q6, Q8. This turns on the (+) neon. When resistance measurements are programed, a high input to Q2 prevents either neon from being lit and there is no polarity readout.

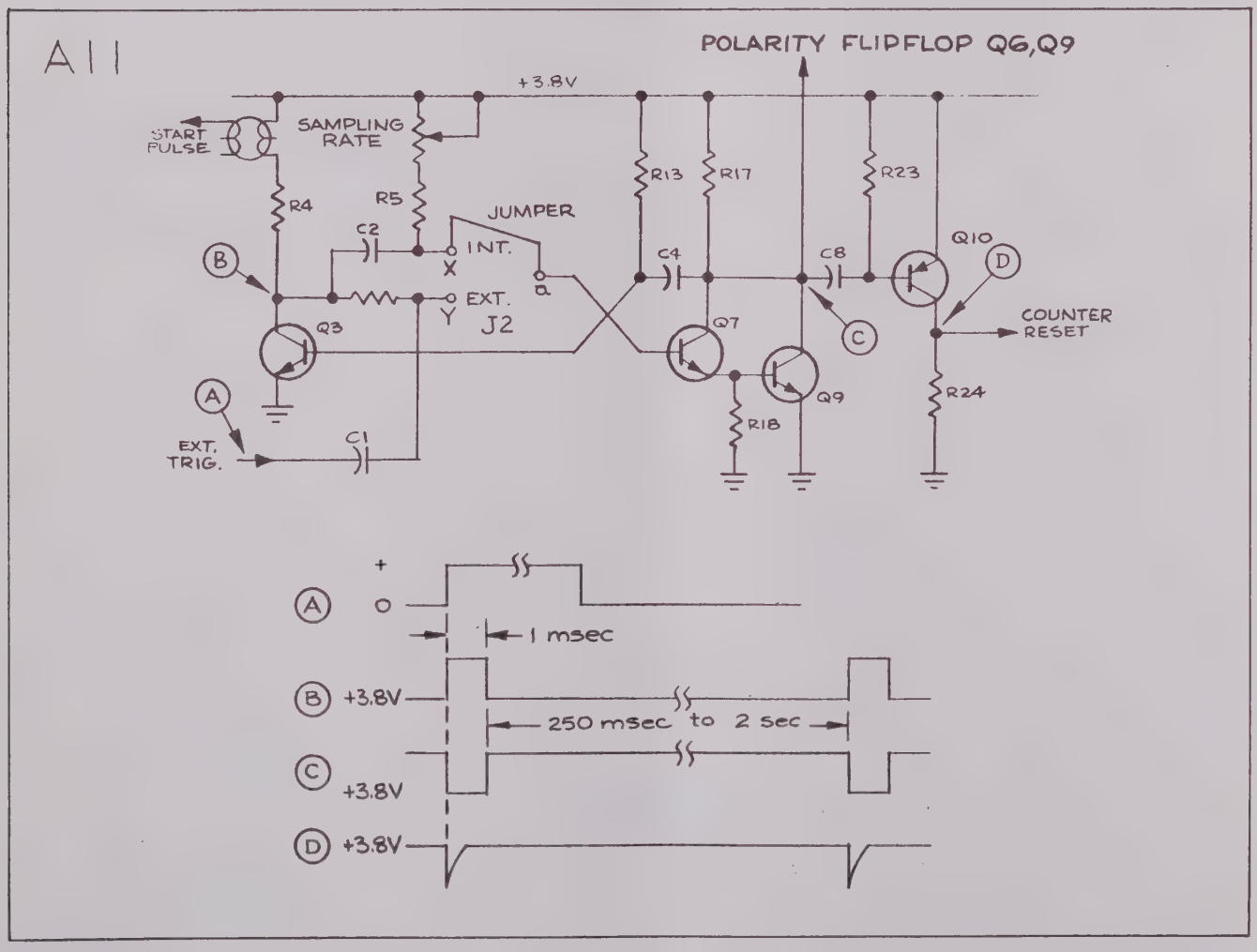


Figure 4-31 Sampling Rate Circuit

4-97. SAMPLING RATE CIRCUIT

4-98. The basic circuit for the sampling rate circuit is shown in figure 4-31. The circuit is basically a multivibrator with its mode of operation determined by a jumper placed in connector J2 situated at rear of instrument. Figure 4-31 shows J2 programed for normal instrument operation. Transistor Q3 and darlington connected Q7, Q9 operate as a free-running astable multivibrator with the time constant for one side set by R13, C4, and by C2, R5, and the sampling rate potentiometer, for the other. The 1 msec pulse appearing at the collector of Q7 and Q9 is the start signal fed to the measurement

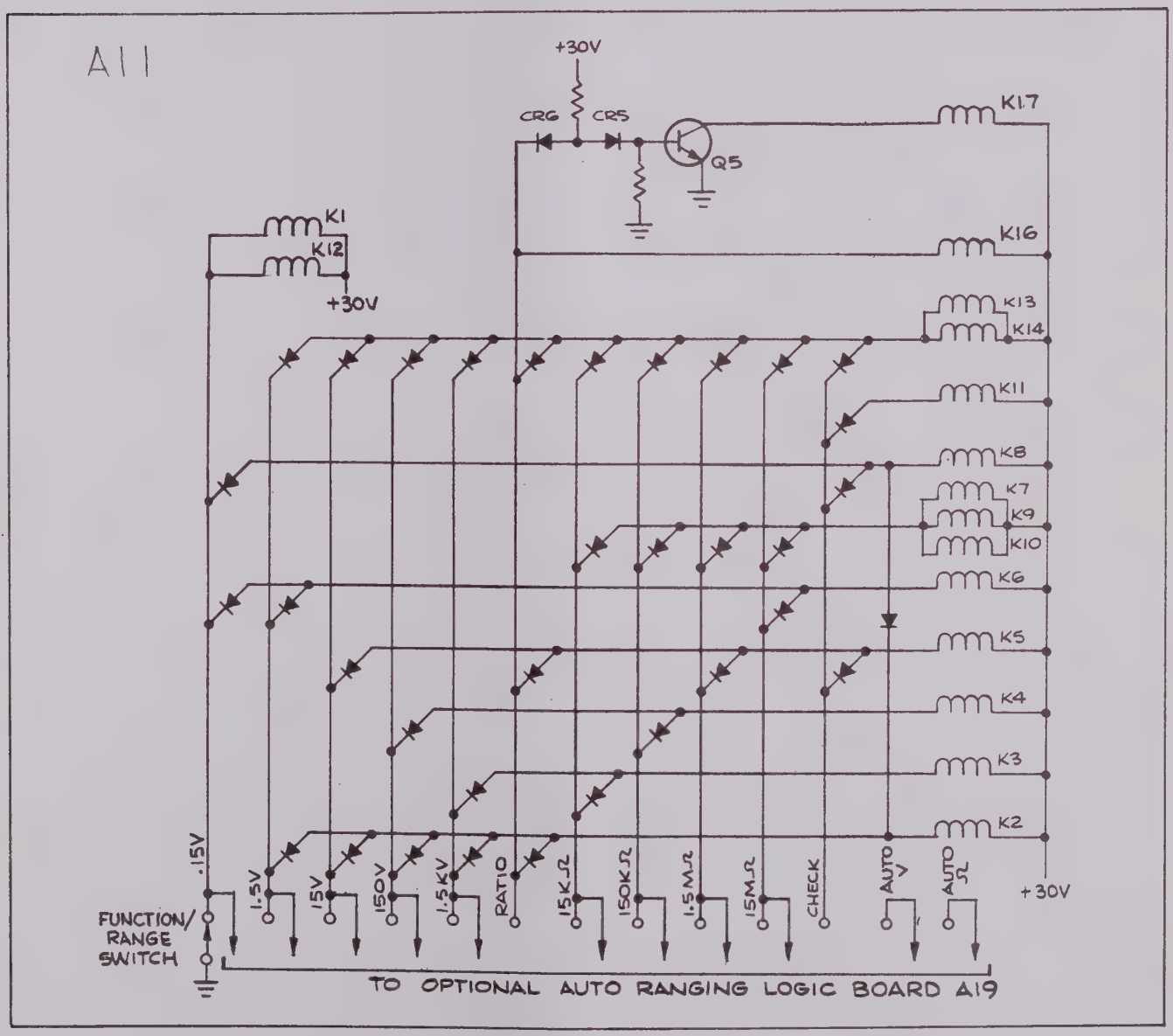


Figure 4-32 Diode Matrix

circuitry. The interval between the pulses may be varied from approximately 250 msec to 2 seconds. When remote operation is programed, the jumper is connected between terminals a and Y. This changes the multivibrator to a single-shot which, when triggered by a positive going external trigger, produces a 1 msec start pulse. Transistor Q10, coupled by C8 to the collector of Q7 and Q9, produces a negative going spike at the beginning of the start pulse that is used to reset the readout counter.

4-99. DIODE MATRIX

4-100. The basic circuit for the diode matrix controlling operation of the reed relays in range assembly A16 is shown in figure 4-32. In manual operation, the wiper of the Function/Range switch connects each line of the matrix to the +30 volt return and provides a current path for the 30 volt relay energising voltage. For example, when the .15 volt position is selected, relays K1, K6, K8 and K12 are energised. Transistor Q5 is an inverter controlling operation of K17---for all positions of the switch except "Ratio", K17 is energised. In the two automatic ranging positions of the switch, the matrix line connected to the +30 volt return is determined by the automatic ranging logic described in Appendix E.

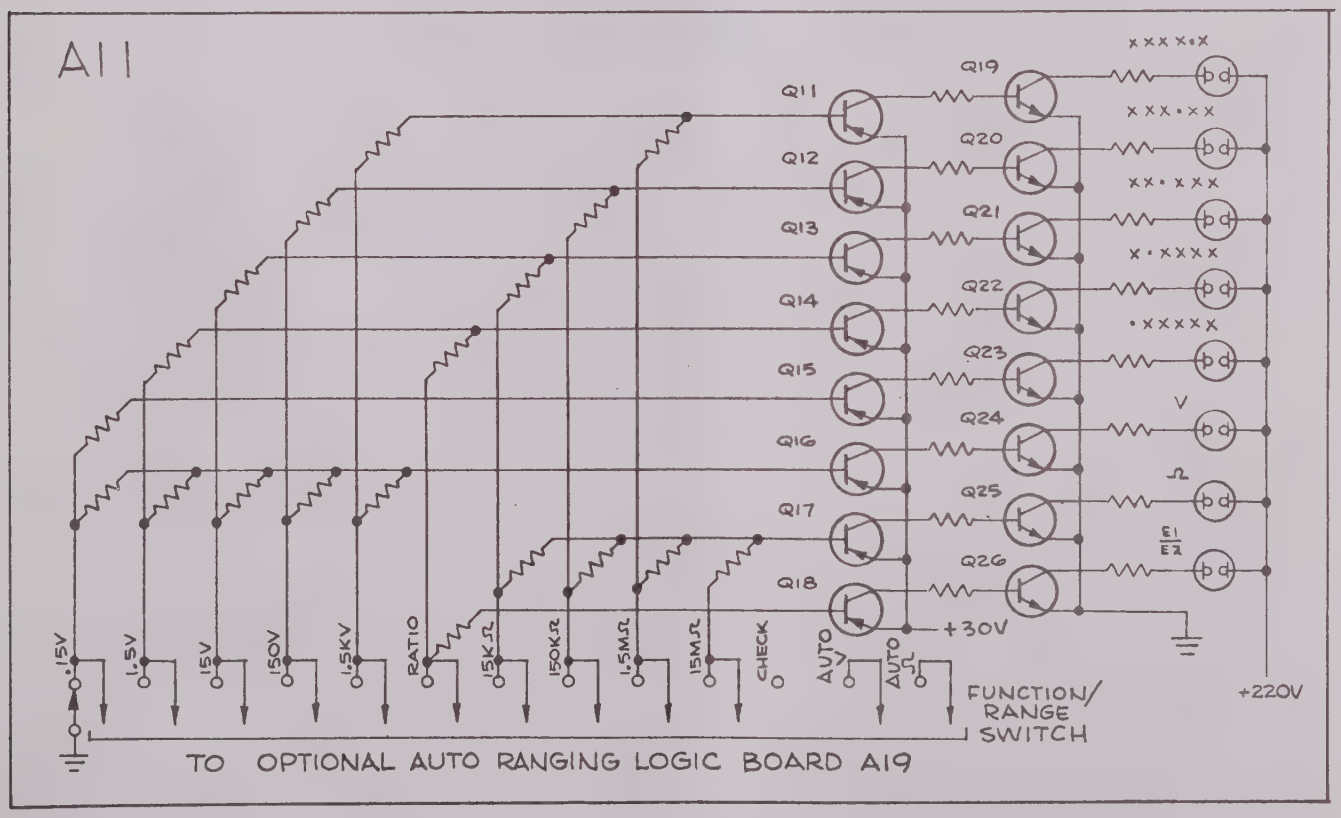


Figure 4-33 Resistor Matrix and Drivers

4-101. RESISTOR MATRIX AND DRIVERS

4-102. The basic circuit for the resistor matrix and drive circuitry controlling the decimal point and measurement unit indicators is shown in figure 4-33. In operation, the wiper of the Function/Range switch provides a ground return for the base emitter junction of Q11 through Q18. The transistors thus grounded are turned on and provide current drive to saturate associated transistors Q19 through Q26 to give the desired decimal point and units readout. During automatic ranging, indicators turned on are determined by the automatic ranging logic. In figure 4-33, the .15 volt position is shown selected. This saturates Q15, Q16, and Q23, Q24, turning on the ".XXXXX" decimal point the "V" indicators.

4-103. DECIMAL POINT ENCODER BOARD A18

4-104. Decimal point neon lamp drivers Q19 through Q23 are also connected to plug-in card A18, a decimal-to-binary encoder that furnishes, for external use, 3-bit BCD signals showing the decimal point position (range) that the instrument is in when a measurement is performed. See figure 5-32 for full schematic of encoder. A basic diagram of the encoder and its associated circuitry on board A11 is shown in figure 4-34 and table 3-1 gives the binary-coded output for each of the five possible ranges.

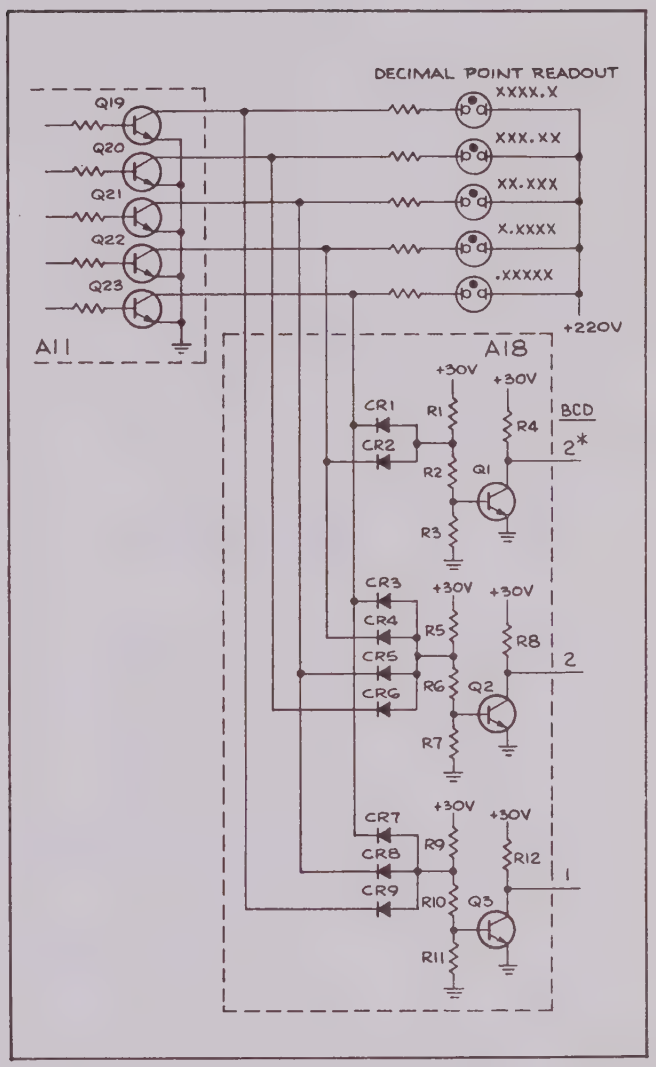


Figure 4-34 Decimal Point Encoder

SECTION V
MAINTENANCE

5-1. SCOPE OF SECTION

5-2. This section contains information on calibration, maintenance, and troubleshooting procedures for the Model 7100.

5-3. TEST EQUIPMENT REQUIRED

5-4. Table 5-1 lists the test equipment used by the factory for all tests detailed in this section. The equipment used at the factory is calibrated with standards which are directly traceable to the National Bureau of Standards, Washington, D.C. The dc voltage working standard is calibrated with a test uncertainty of ±0.0005%. The precision resistor working standards are calibrated with a measurement accuracy of ±0.005%.

5-5. PERFORMANCE CHECK

5-6. This procedure verifies the specifications of the Model 7100. (On limited readout versions of the instrument, use only applicable portions of check.) It can be used upon receipt of a new instrument, for routine preventive maintenance, and following repair.

Table 5-1 Test Equipment Required

Nomenclature	Type and Manufacturer	Critical Specifications
Precision DC High Voltage Supply	Model 1565 Power Designs Inc.	1 volt to 1000 volts, 0 to 15 ma Regulation .001%
Precision Resistance Decade	Model DSI66 Dial-A-Stat	Total resistance 12 MΩ Highest decade Ω/step - 1 MΩ Lowest decade Ω/step - 10 Ω Accuracy: ±0.01%
Precision DC Voltmeter	Model 330 Electro Scientific Ind.	Readout range: 10 μv to 1000 volts Accuracy: ±.003%
Precision Fixed Resistors		Value: 10 kΩ, 100 kΩ, 1 MΩ Tolerance: ±.005%
Precision DC Voltage Supply	RVL-1 Fairchild	0 to 10 volts Regulation: .001%

5-7. RESISTANCE MEASUREMENT

5-8. To check resistance measurement mode of operation, carry out following procedure:

a. Connect Dial-A-Stat resistance decade to OHMS input and set decade to zero.

Table 5-2 Resistance Measurement Check

Function Switch	Input Resistance	Readout (Ω) Min	Max
15 K OHMS	00.000	00.001	00.001
	00.009kΩ	00.008	00.010
	00.099	00.098	00.100
	00.999	00.998	01.000
	09.999	09.996	10.002
	14.999	14.996	15.002
150 K OHMS	000.00	000.01	000.01
	000.09kΩ	000.08	000.10
	000.99	000.98	001.00
	009.99	009.98	010.00
	099.99	099.96	100.02
	149.99	149.96	150.02
1.5 M OHMS	.0000	0.0001	0.0001
	0.0001MΩ	0.0000	0.0002
	0.0099	0.0098	0.0100
	0.0999	0.0998	0.1000
	0.9999	0.9996	1.0002
	1.4999	1.4996	1.5002
15 M OHMS	00.000	00.001	00.001
	00.009MΩ	00.008	00.010
	00.099	00.098	00.100
	00.999	00.998	01.000
	09.999	09.996	10.002
	14.999	14.996	15.002

b. Set instrument Function/Range switch to 15 K OHMS.

c. Check that readout is 00.001kΩ. Consult table 5-2 and repeat procedure for remainder of settings detailed. Note that in each case readout falls within tolerance. If this is not the case consult table 5-5.

d. Remove decade box.

5-9. VOLTAGE MEASUREMENT

5-10. To check voltage readout, proceed as follows:

a. Connect output of programable voltage source to VOLTS input. Connect precision voltmeter to monitor output of voltage source. Set supply for zero output.

b. Set instrument Function/Range switch to .15 VOLTS.

c. Check that readout is between -0000.2 and +0000.2 V. Program supply for remainder of settings listed in table 5-3 and check that each reading is within tolerance. Consult table 5-5 for trouble-shooting information if some readings are outside tolerance.

5-11. VOLTAGE RATIO MEASUREMENT

5-12. To check voltage ratio readout, carry out following steps:

a. Set instrument Function/Range switch

Table 5-3 Voltage Measurement Check

Function Switch	Input Voltage	Readout (Volts) Min	Max
.15 VOLTS	.00000	-.00002	+.00002
	.00010	.00008	.00012
	.00121	.00119	.00123
	.01232	.01230	.01234
	.02343	.02341	.02345
	.03454	.03452	.03456
	.05676	.05673	.05679
	.06787	.06784	.06790
	.07898	.07895	.07901
	.08999	.08996	.09002
	.09565	.09562	.09568
	.14998	.14995	.15001
1.5 VOLTS	0.0000	-0.0001	0.0001
	0.0001	0.0000	0.0002
	0.0099	0.0098	0.0100
	0.0999	0.0998	0.1000
	0.9999	0.9997	1.0001
	1.4999	1.4997	1.5001
15 VOLTS	00.000	-00.001	00.001
	00.009	00.008	00.010
	00.099	00.098	00.100
	00.999	00.998	01.000
	09.999	09.997	10.001
	14.999	14.997	15.001
150 VOLTS	000.00	-000.01	000.01
	000.09	000.08	000.10
	000.99	000.98	001.00
	009.99	009.98	010.00
	099.99	099.97	100.01
	149.99	149.97	150.01
1000 VOLTS	0000.0	-0000.1	0000.1
	0000.9	0000.8	0001.0
	0009.9	0009.8	0010.0
	0099.9	0099.8	0100.0
	0999.9	0999.7	1000.1

to RATIO 1.5.

b. Connect 10.000 volts to connector J6 at rear of meter. Connect programable voltage source to VOLTS input and program for output of 10.000 volts.

c. Check that readout is between 0.9998 and 1.0002 E1/E2. Repeat for remainder of settings listed in table 5-4.

d. Remove test equipment.

Table 5-4 Ratio Measurement Check

Function Switch	Ref Input	Input Voltage	Readout (Ratio) Min	Max
RATIO	10.000	10.000	0.9998	1.0002
	10.000	15.000	1.4998	1.5002
	10.000	5.0000	0.4999	0.5001
	10.000	1.0000	0.0999	0.1001
	10.000	0.1000	0.0099	0.0101
	5.0000	7.5000	1.4997	1.5003
	5.0000	5.0000	0.9997	1.0003
	5.0000	1.0000	0.1999	0.2001
	15.000	15.000	0.9997	1.0003
	15.000	5.0000	0.3331	0.3335

5-13. PERIODIC MAINTENANCE

5-14. The Model 7100 requires little periodic maintenance. The procedure in the following paragraphs may be used when maintenance is performed on a regular basis.

5-15. INSPECTION

5-16. Remove top and bottom covers of the instrument. Inspect the chassis and mounted components for damage, signs of overheating, etc. Remove circuit boards and inspect for damage or signs of failure. Using low pressure, dry, compressed air, blow out any dust accumulation.

5-17. Rotate all front panel controls through their full range, noting any binding or rough action.

5-18. Following inspection, replace all circuit boards, and covers. Make performance check detailed in paragraphs 5-5 through 5-10.

5-19. AIR FILTER

5-20. When the air filter has trapped enough dirt to impede airflow, it should be removed and cleaned as follows:

a. Remove filter element.

b. Wash filter in solution of warm water and detergent.

c. Dry filter thoroughly and replace.

CAUTION

DO NOT USE COATING COMPOUND FOR FILTER. FILTER IS DESIGNED FOR DRY USE.

5-21. FAN LUBRICATION

5-22. At yearly intervals, the fan motor should be lubricated using a hypodermic-type oiler available from the fan manufacturer. Use the following procedure:

a. Holding the oiler at about 45° to the surface of the label, pierce the label at the point marked "oil".

b. Insert the needle approximately 1/4 inch and inject a few drops of oil. Do not over lubricate. Remove oiler.

5-23. TROUBLE SHOOTING

5-24. If improper operation is evident or suspected use table 5-5 to aid in locating the faulty circuit. However, before attempting extensive trouble shooting make the following checks:

a. Paragraph 5-25 - Power Supply.

b. Paragraph 5-27 - Alignment procedure.

5-25. POWER SUPPLY CHECK

5-26. To check the dc power supplies incorporated in the unit, proceed as follows:

a. Remove top and bottom covers and place instrument on its side.

b. Set power switch to ON.

Table 5-5 Trouble Analysis

Trouble	Possible Cause
All voltage ranges have same excessive percentage full-scale readout error and no error at zero. No error on resistance measurements.	a. +10 volt reference incorrectly adjusted.
Reads only positive voltage accurately.	a. Inverting reference amplifier (plug-in board A2) inoperative.
Decimal readout tubes remain blanked out on all modes. Polarity, decimal point, and unit readout functioning normally.	a. Conversion cycle not ending. Possible cause: 1. Zero crossover of integrator output not being detected. 2. Full scale pulse not resetting input flip-flop. 3. Full scale pulse transformer and/or driver defective
Decimal readout tubes remain blanked out on ratio mode only. Polarity, decimal point, and unit readout functioning normally.	a. External reference. Check that reference, range +5 to +15 volts is connected to J2 at rear of instrument.
Zero drift on lowest range only.	a. Faulty input ranging amplifier (plug-in board A8). b. Thermocouple effects on input leads.
Unstable readout.	a. Test cable incorrectly used - ensure that LO and GUARD terminals are connected together.
15 MΩ range full scale readout low. All other ohms, volts, and ratio ranges within specifications	a. Leakage impedance from HI to LO terminals - 150 kMΩ of leakage will cause a readout error of 1 digit.

Table 5-6 Power Supply Check

Power Supply Location	Output	Connect Voltmeter	Voltage	Tolerance	Adjustment
Board A5	+30 volt regulated	Connector XA5, terminals N and Y	+30 v	±60 mv	Adjustment is detailed in Table 5-7
Board A6	-30 volt regulated	XA6-N and XA5-N	-30 v	±60 mv	
Board A11	+30 volt unregulated	XA11, terminal 22 and CHASSIS jack	+30 v	±5 v	—
	+240 volt unregulated	XA11, terminal 11 and CHASSIS	+240 v	±50 v	—
	3.8 v regulated	XA11, terminal 1 and CHASSIS jack	+3.8 v	±50 mv	R63 board A11
Board A3	-10 volt reference	XA1, terminal E and P	-10 v		Adjustment is detailed in table 5-7.
Board A2	+10 volt reference	XA3, terminal Z and H	+10 v		

c. Connect voltmeter between each of the points listed in table 5-6 and check that all outputs are within tolerance. Make adjustments where necessary and replace covers.

5-27. ALIGNMENT PROCEDURE

5-28. Table 5-7 details the procedure to be followed to align the Model 7100/7101 for correct readout on all ranges. (Alignment procedures for other Models are contained in appendices A through D.) The procedure must be carried out in the order given as there is interaction between some of the adjustments. Figure 5-1 shows the location of the alignment controls.

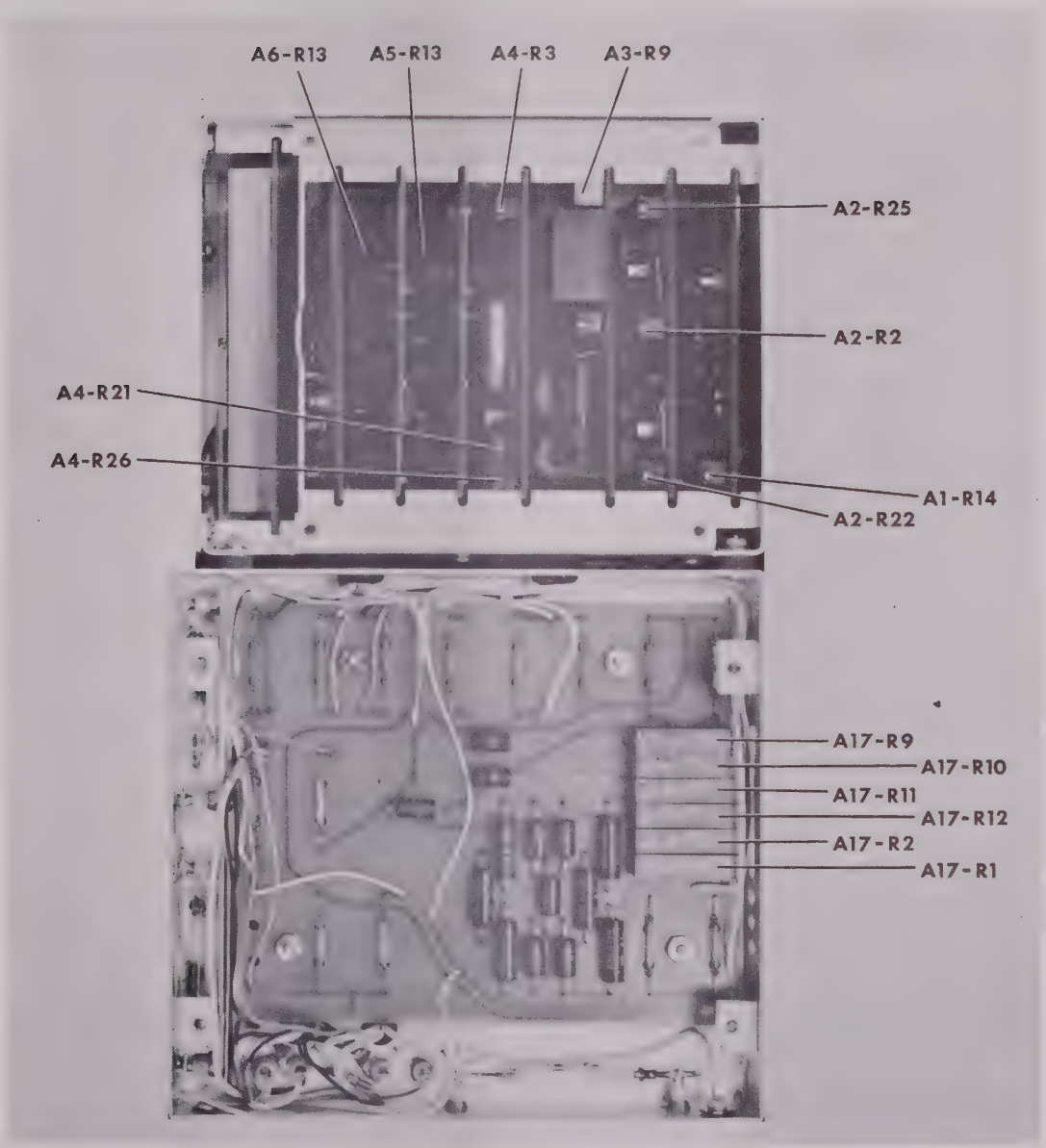


Figure 5-1 Calibration Adjustment Controls

Table 5-7 Alignment Procedure, Model 7100/7101

Step	Function Range Switch	Test Condition	Adjustment
1			Connect a voltmeter between chassis ground and XA11 pin 1. Adjust A11-R63 for 3.8 v ±50 mv.
2	15 VOLTS	Connect +15.7 volts to VOLTS input	Connect a voltmeter between connector XA5-Y and XA5-N. Adjust A5-R13 for output of +30 volts ±0.5%. Vary input voltage, to VOLTS jack, between +15.4 and +15.9 and check that overload light comes on.
3	15 VOLTS	Connect -15.7 volts to VOLTS input	Connect a voltmeter between XA6-N and XA5-N. Adjust A6-R13 for -30 volts ±0.5%. Vary input voltage to VOLTS jack between -15.4 and -15.9 and check that overload light comes on.
4	15 VOLTS	Alternately apply +30 and -30 millivolts to VOLTS input	Adjust A2-R22 for symetrical readout.
5	15 VOLTS	Apply +1 volt to VOLTS input	Set A4-R21 to mid-position. Connect a jumper between collector and emitter of Q11 on A4 and note readout. Remove jumper and adjust A4-R26 until readout is approximately eleven (11) digits lower than when jumper is connected.
6	15 VOLTS	Alternately apply +10 and -10 millivolts to VOLTS input	Adjust A2-R2 for readout of ±00.010 v. If necessary, readjust A2R22 for a symetrical output.

Table 5-7 Alignment Procedure, Model 7100/7101 (Cont)

Step	Function Range Switch	Test Condition	Adjustment
7	.15 VOLTS	Alternately apply +100 and -100 microvolts to VOLTS input.	Adjust A4-R3 for a symetrical reading and A4-R21 for a readout of ±.00010 V. If A4-R21 is adjusted, repeat step 5 without changing new setting of A4-R21.
8	15 VOLTS	Alternately apply +10 and -10 millivolts to VOLTS input.	Repeat step 6.
9	15 VOLTS	Apply 15.0 volts to	a) Measure input voltage applied to VOLTS input, with a Model 7100 meter or similar instrument. b) Connect HI terminal of same measuring instrument to TP7-A16 and LO terminal to TP2-A16. Note reading. c) Connect HI terminal to TP2-A16 and LO terminal to either side of Relay K8. Note reading. d) Adjust A17-R1 and/or A17-R11 until readings noted in steps b) and c) are identical and the same as the reading noted in step a)
10	CHECK	Short LOW and GUARD together on VOLTS input.	Adjust A1~~4~~ A1 R14 for readout of 10000 Replace cover on A16.
11	15 K OHMS	Connect a 10 k ohm, ±0.005% resistor to OHMS input.	Adjust A17-R9 for readout of 10.000 k ohm
12	150 K OHMS	Connect a 100 k ohm, ±0.005% resistor to OHMS input.	Adjust A17-R10 for readout of 100.00 k ohm

Table 5-7 Alignment Procedure, Model 7100/7101 (Cont)

Step	Function Range Switch	Test Condition	Adjustment
13	1.5 M OHMS	Connect a 1.0 M ohm, ±0.005% resistor to OHMS input	Adjust A17-R11 for readout of 1000.0 k ohm.
14	CHECK	Short LOW and GUARD together on VOLTS input jack.	Adjust A17-R1 for readout of 10000
15	15 VOLTS	Apply +15 volts, +0.005% to VOLTS input	Adjust A3-R9 for readout of +15.000 v.
16	15 VOLTS	Apply -15 volts, ±0.005% to VOLTS input	Adjust A2-R25 for readout of -15.000 v.
17	1.5 VOLTS	Apply +1.5 volts, ±0.005% to VOLTS input	Adjust A17-R12 for readout of +1.5000 v.
18	1.5 VOLTS	Apply -1.5 volts, ±0.005% to VOLTS input	Check that readout is -1.5000 v.
19	.15 VOLTS	Apply ±0.15 volts, ±0.005%, to VOLTS input	Adjust A17-R2 for readout of ±.15000 v.
20	15 M OHMS	Connect a 10 M ohm, ±0.01% resistor to OHMS input	Check that readout is 10000 k ohms.
21	RATIO	Apply +5 volts, ±0.005% to VOLTS input and +5 volts, ±0.005% to J6	Check that reading is -1.0000 $\frac{E1}{E2}$ ±3 counts
22	RATIO	+15 volts to VOLTS input and +15 volts to J6	Check that reading is +1.00 $\frac{E1}{E2}$ ±3 counts
23	RATIO	Apply -5 volts, ±0.005% to VOLTS input and +5 volts, ±0.005% to J6	Check that reading is -1.0000 $\frac{E1}{E2}$ ±3 counts

5-29. COMPONENT LOCATION, SCHEMATIC DIAGRAMS, AND WAVEFORMS

5-30. Figures 5-2 through 5-33 show a) location of components on printed circuit boards b) assembly wiring and schematic diagrams and c) typical operating waveforms and voltage levels.

NOTE

The waveforms and voltage levels were measured on a serviceable Model 7100, using an oscilloscope. Similar measurements on other instruments may vary in duration and amplitude by ±10%.

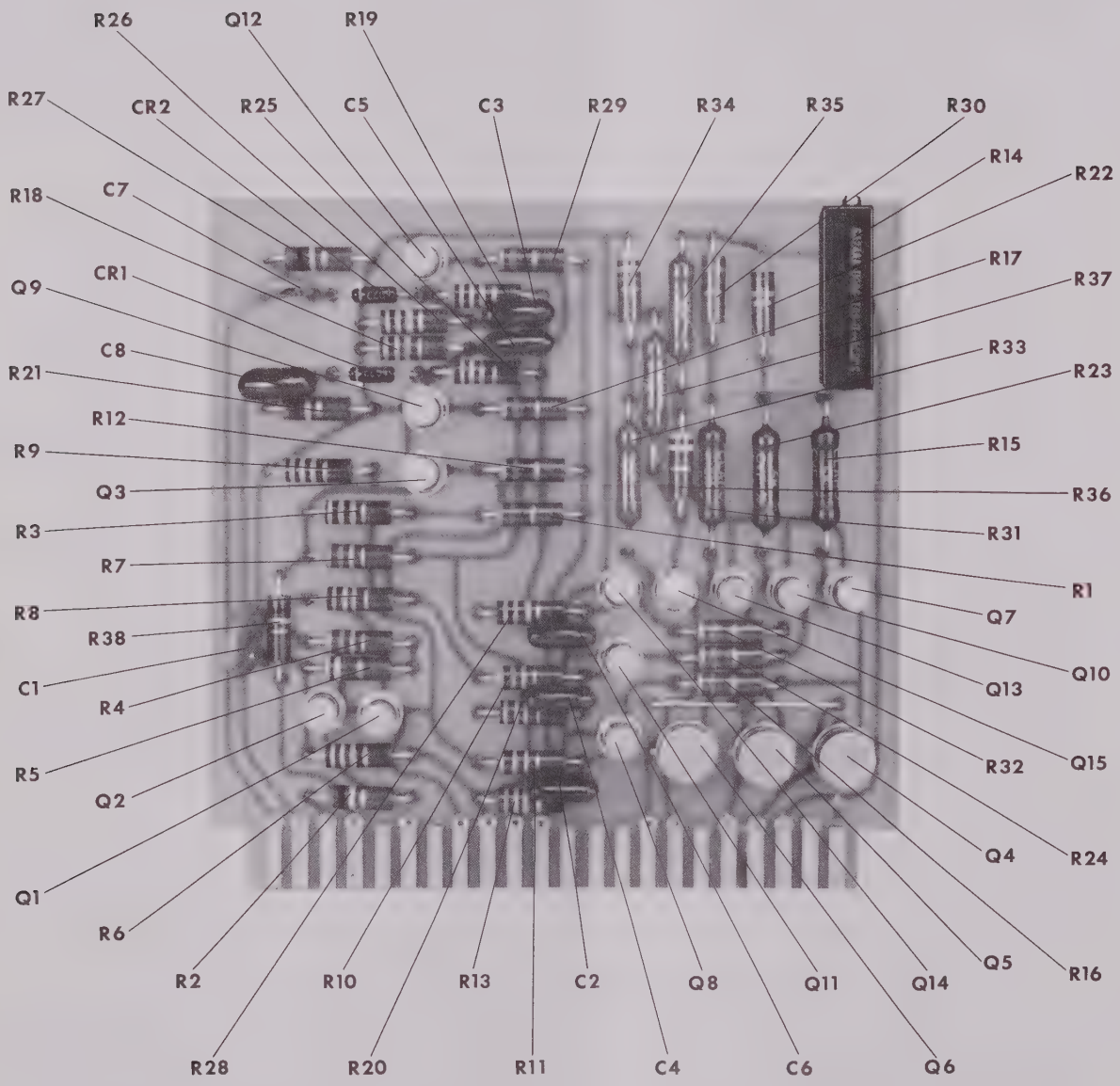


Figure 5-2 Input Switch Board A1 Parts Identification

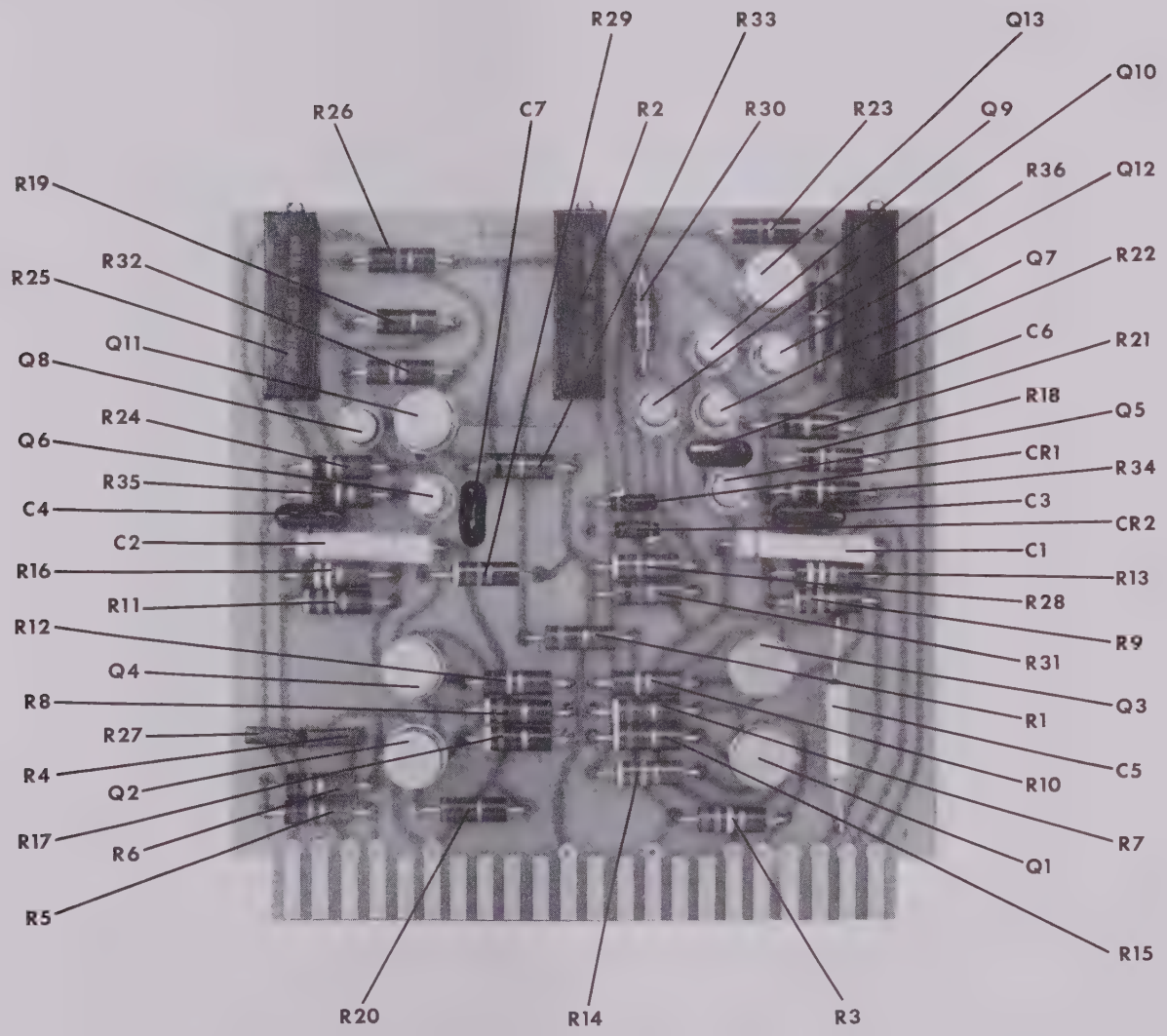


Figure 5-3 Dual Differential Amplifier Board A2 Parts Identification

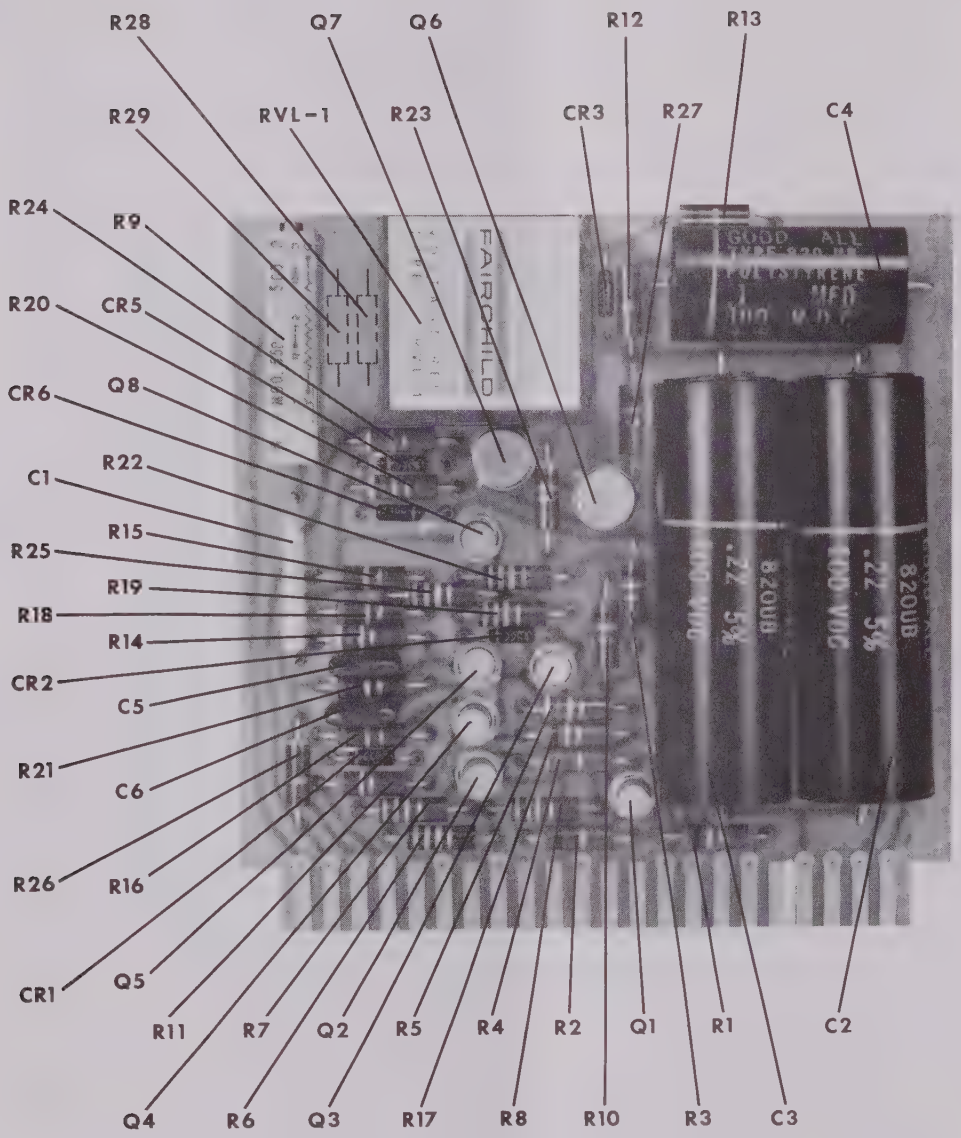


Figure 5-4 Integrator Switch Board A3 Parts Identification

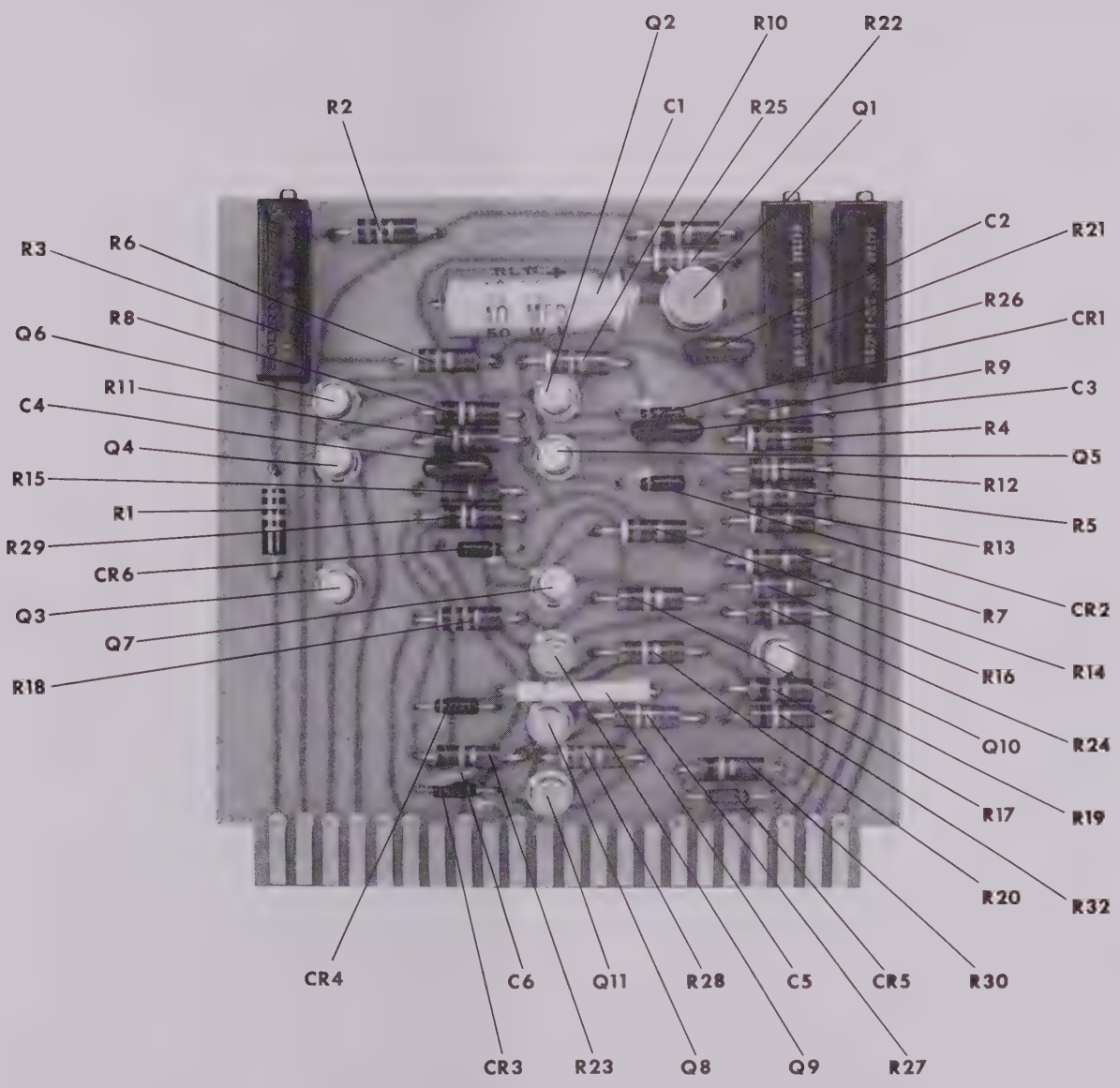


Figure 5-5 Clock Board A4 Parts Identification

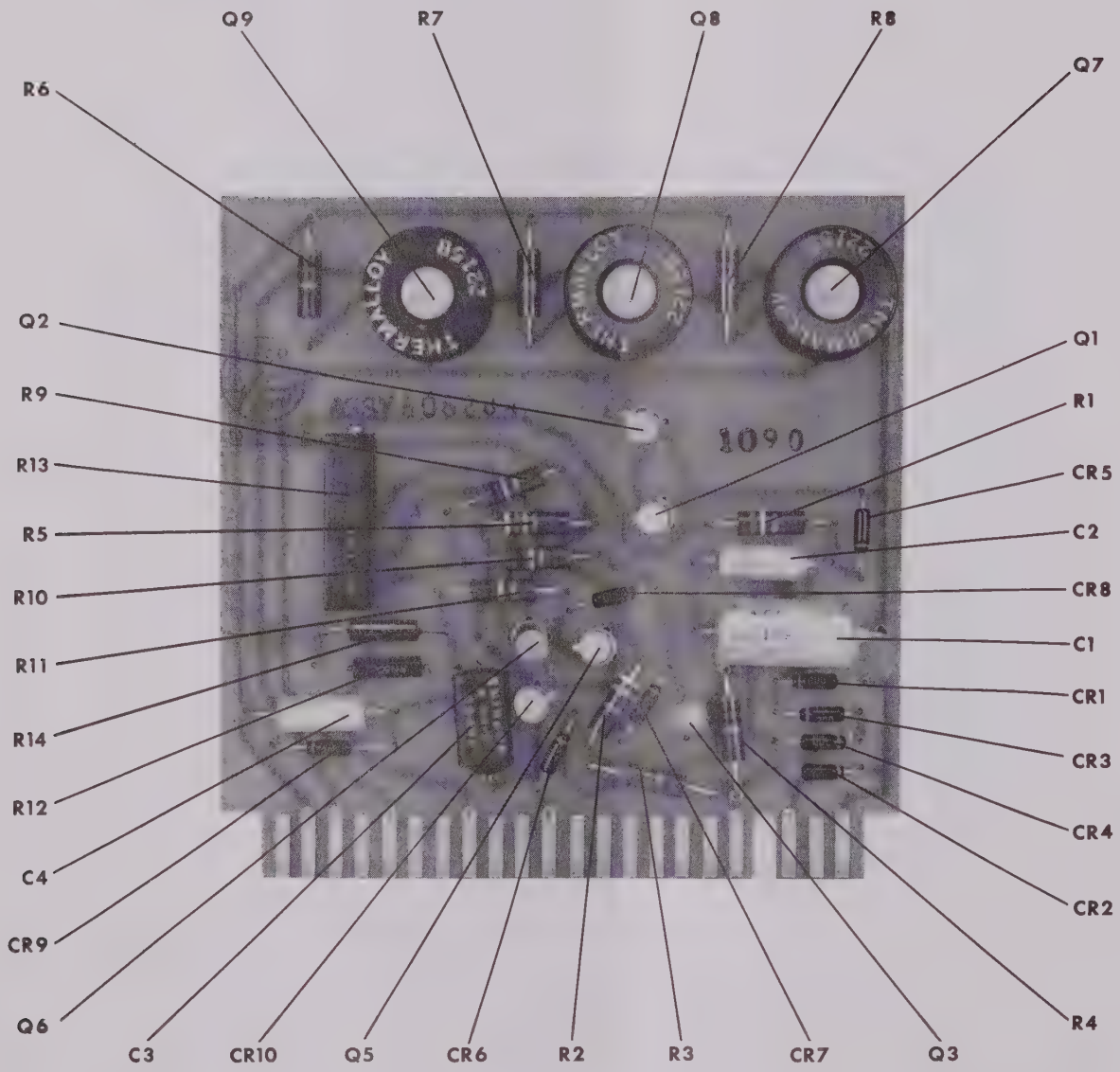


Figure 5-6 Power Supply PSR-1 Board A5/A6 Parts Identification

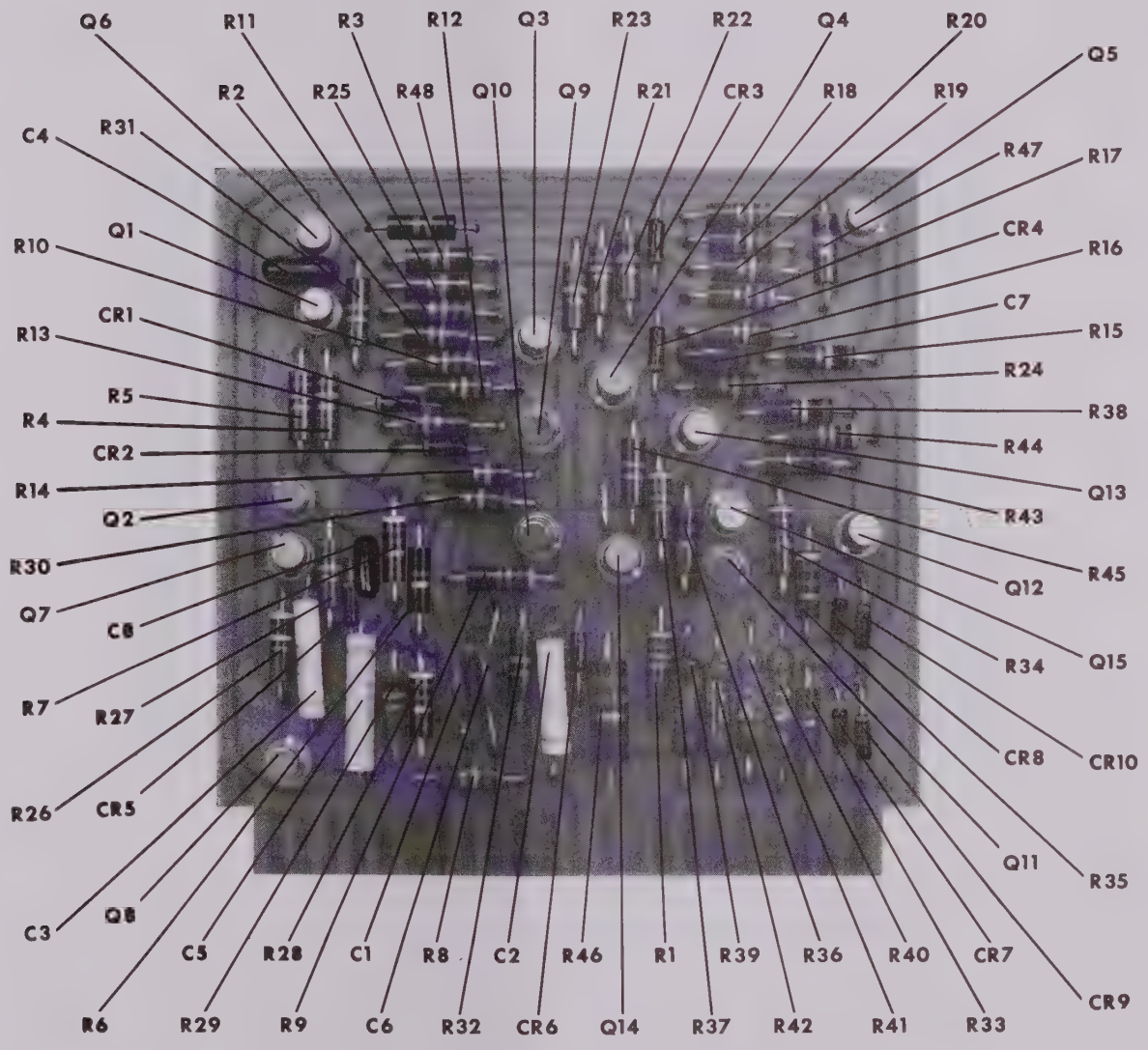


Figure 5-7 Clamp Board A7 Parts Identification

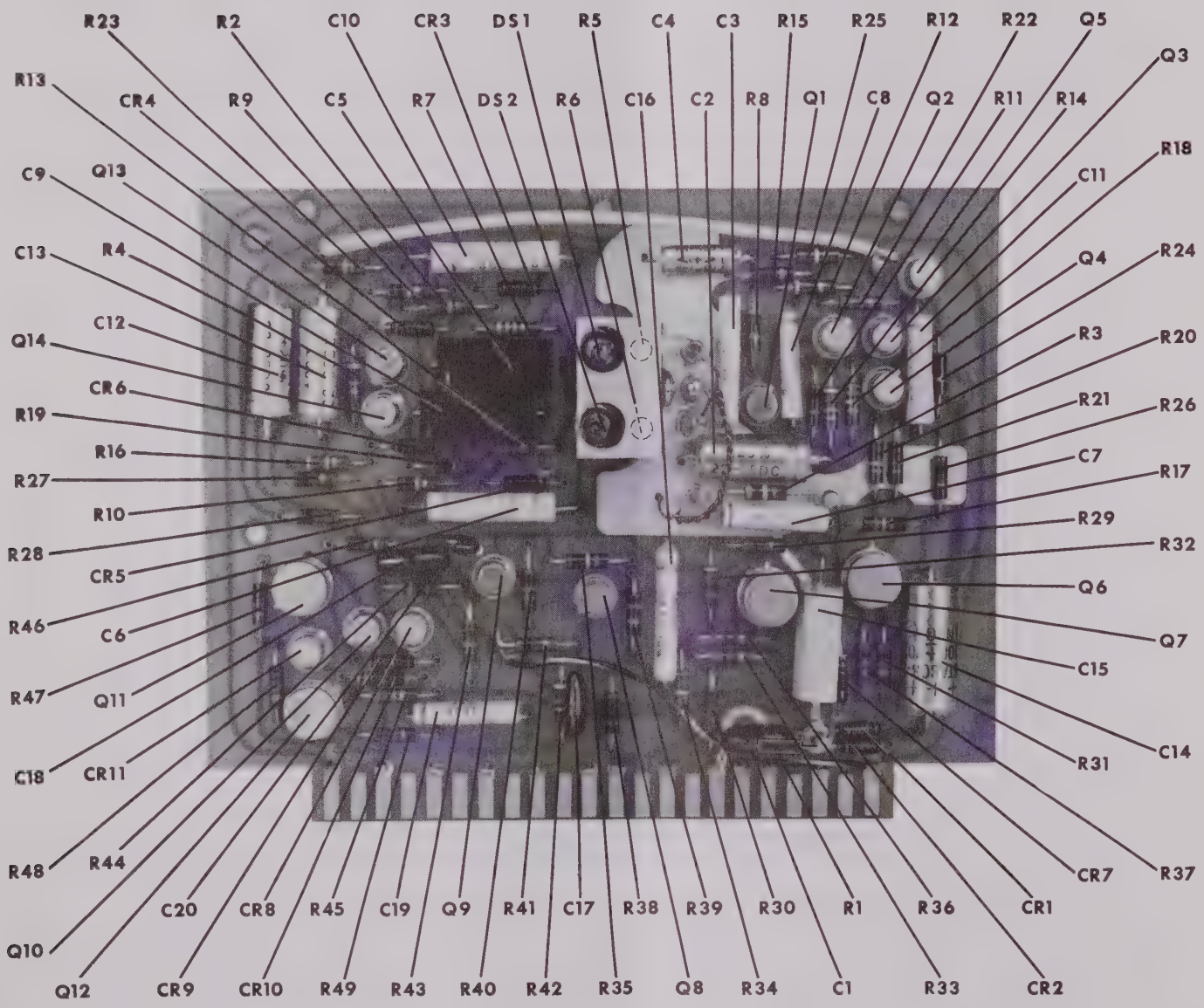


Figure 5-8 Input Ranging Amplifier Board A8 Parts Identification

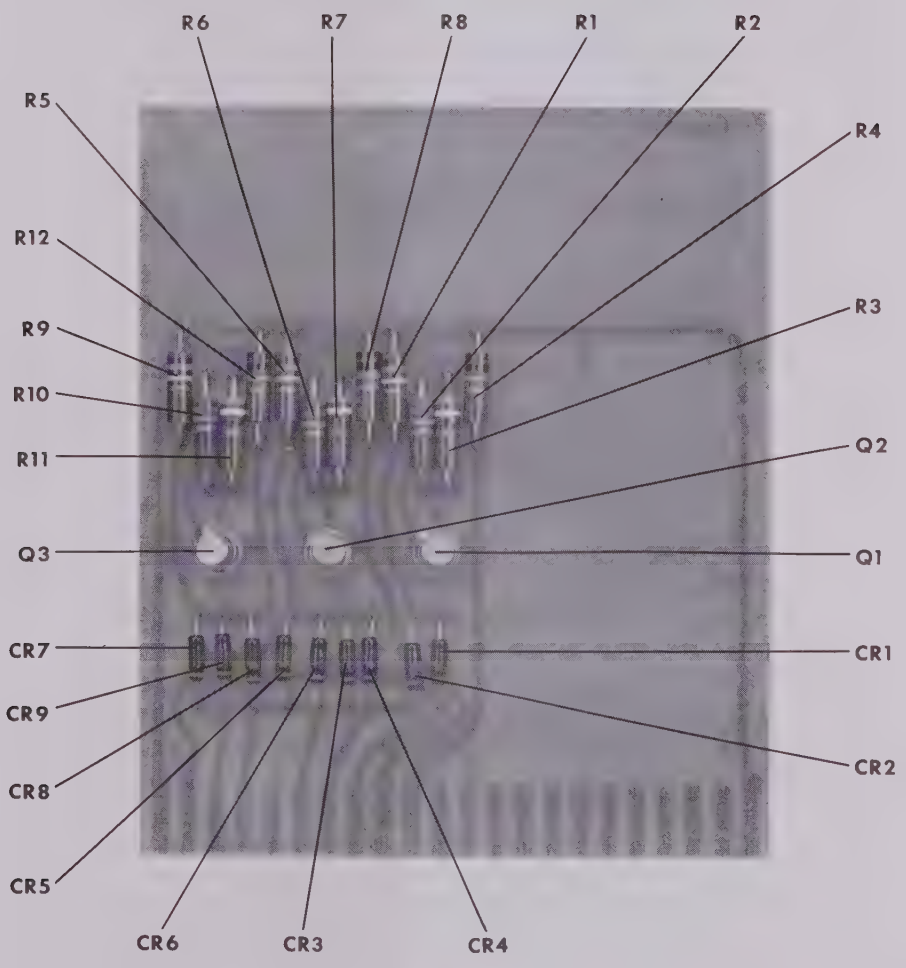


Figure 5-8A Decimal Point Encoder Board A18 Parts Identification

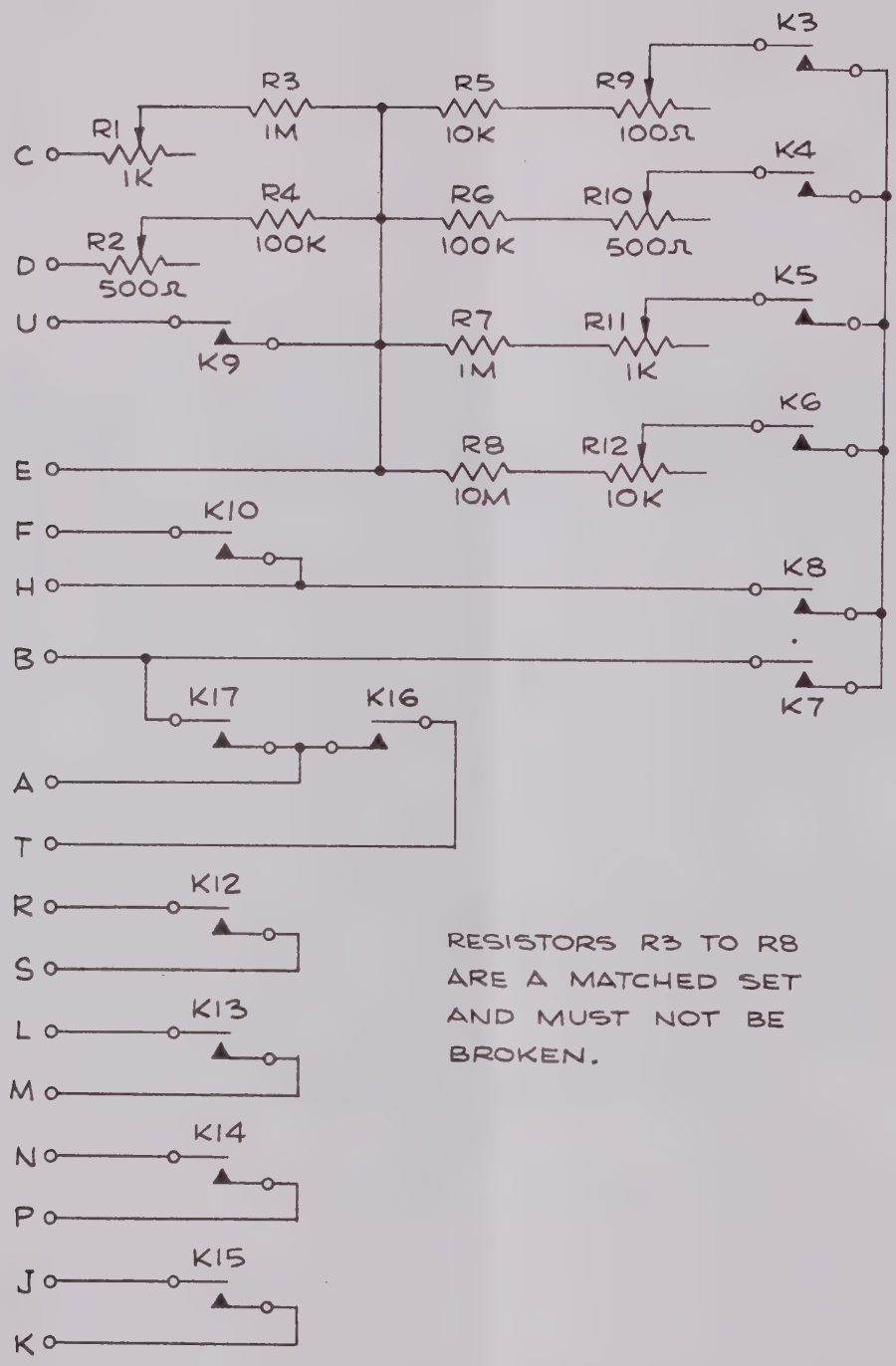
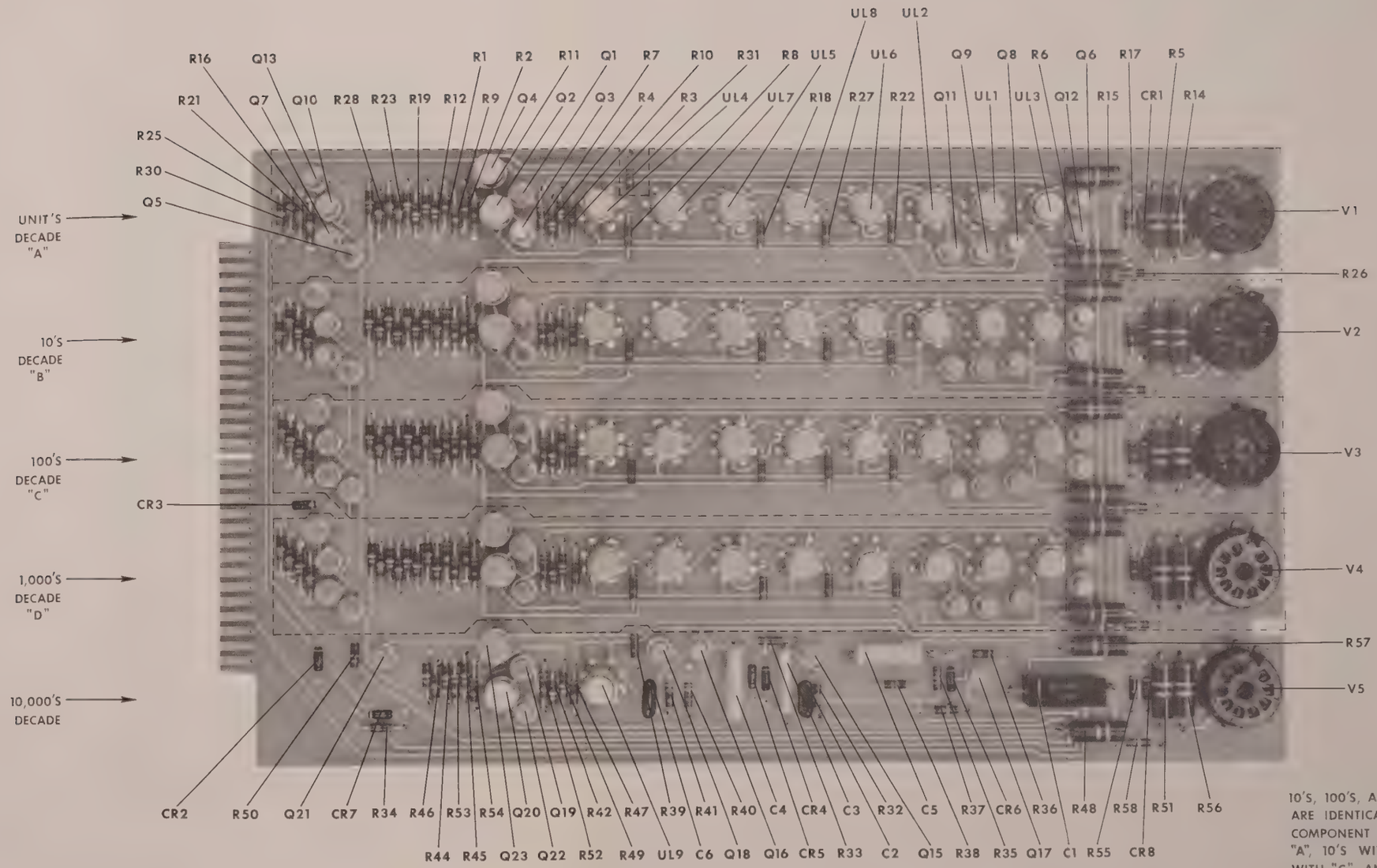


Figure 5-9 Range Board A17 Schematic



THE UNIT'S, 10'S, 100'S, AND 1,000'S DECADES ARE IDENTICAL. SUFFIX UNIT'S COMPONENT REFERENCE WITH "A", 10'S WITH "B", 100'S WITH "C", AND 1,000'S WITH "D".

Figure 5-10 Counter Display Board A10
Parts Identification

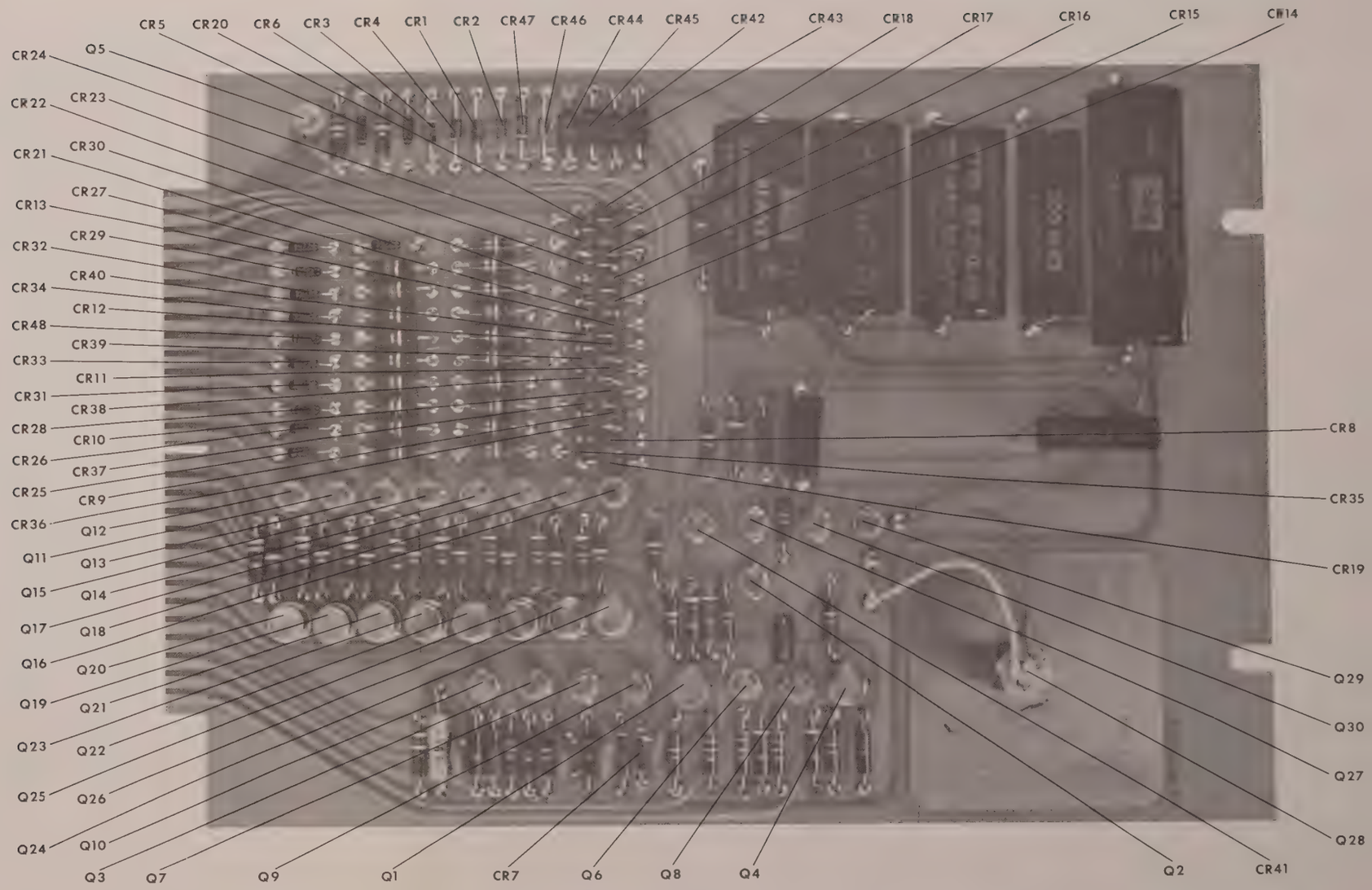


Figure 5-11 Power Supply And Logic Board All Parts Identification (Sheet 1 of 2)

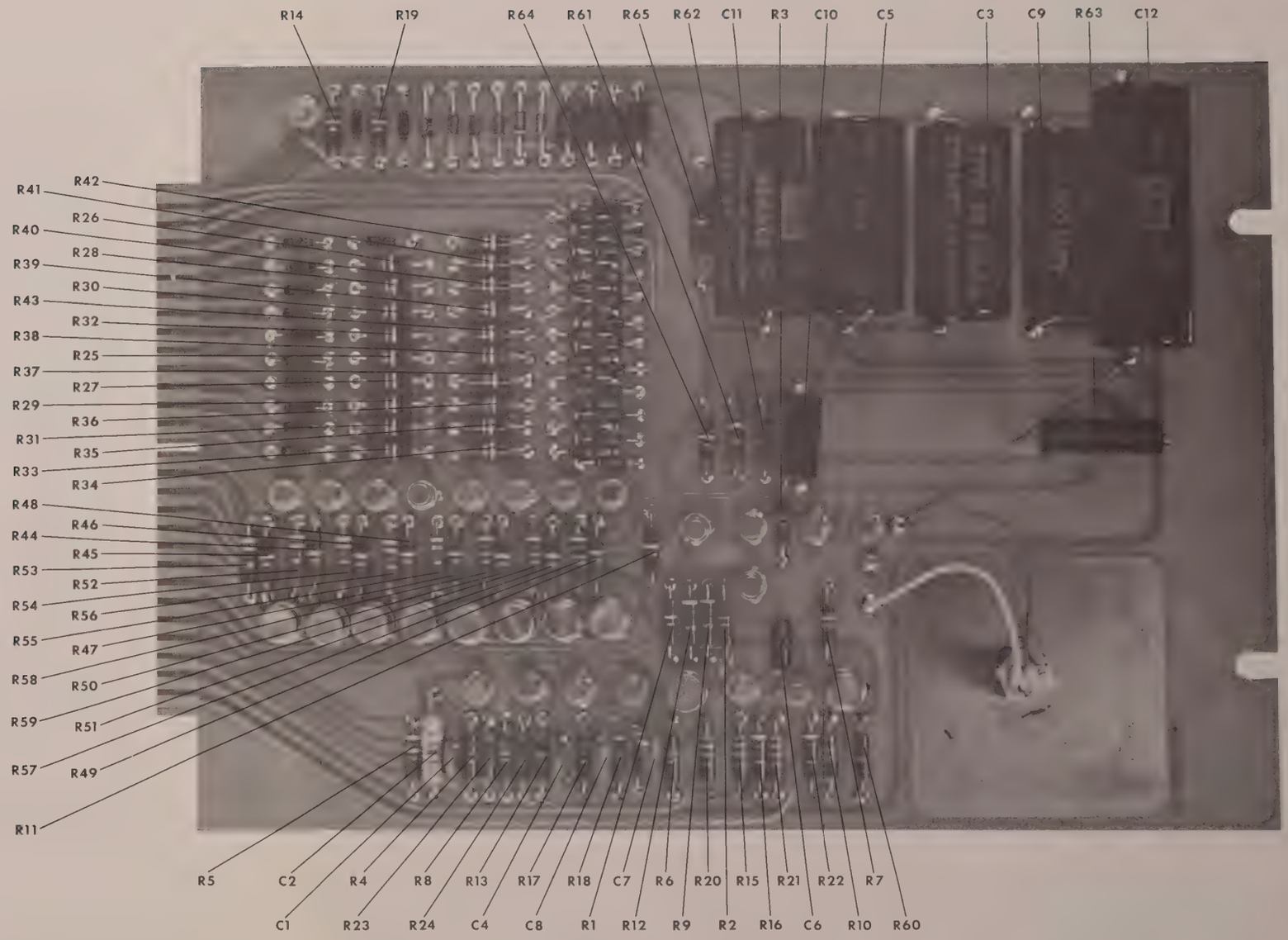


Figure 5-11 Power Supply And Logic Board All Parts Identification (Sheet 2 of 2)

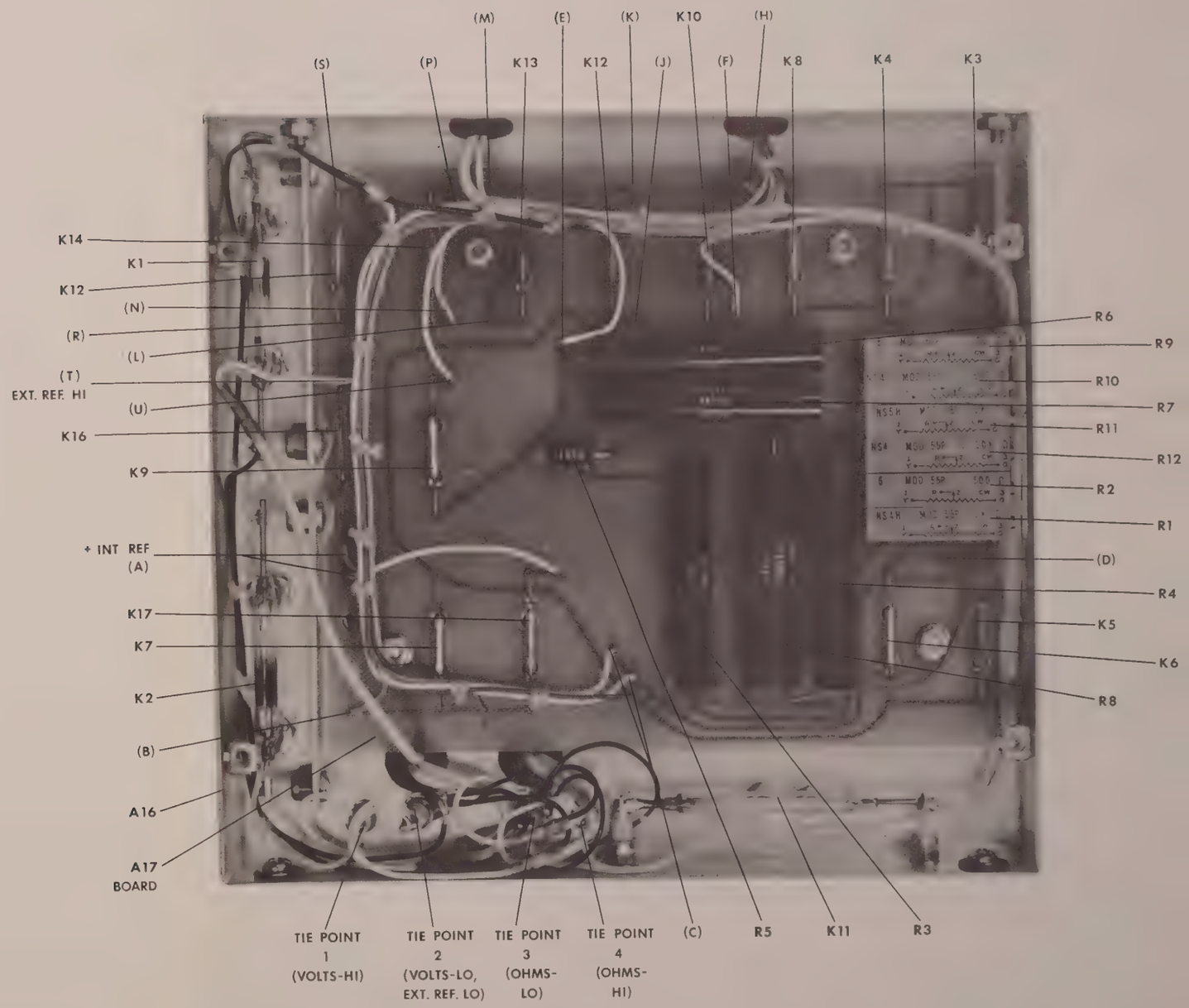


Figure 5-12 Range Assembly A16 And Board A17 Parts Identification

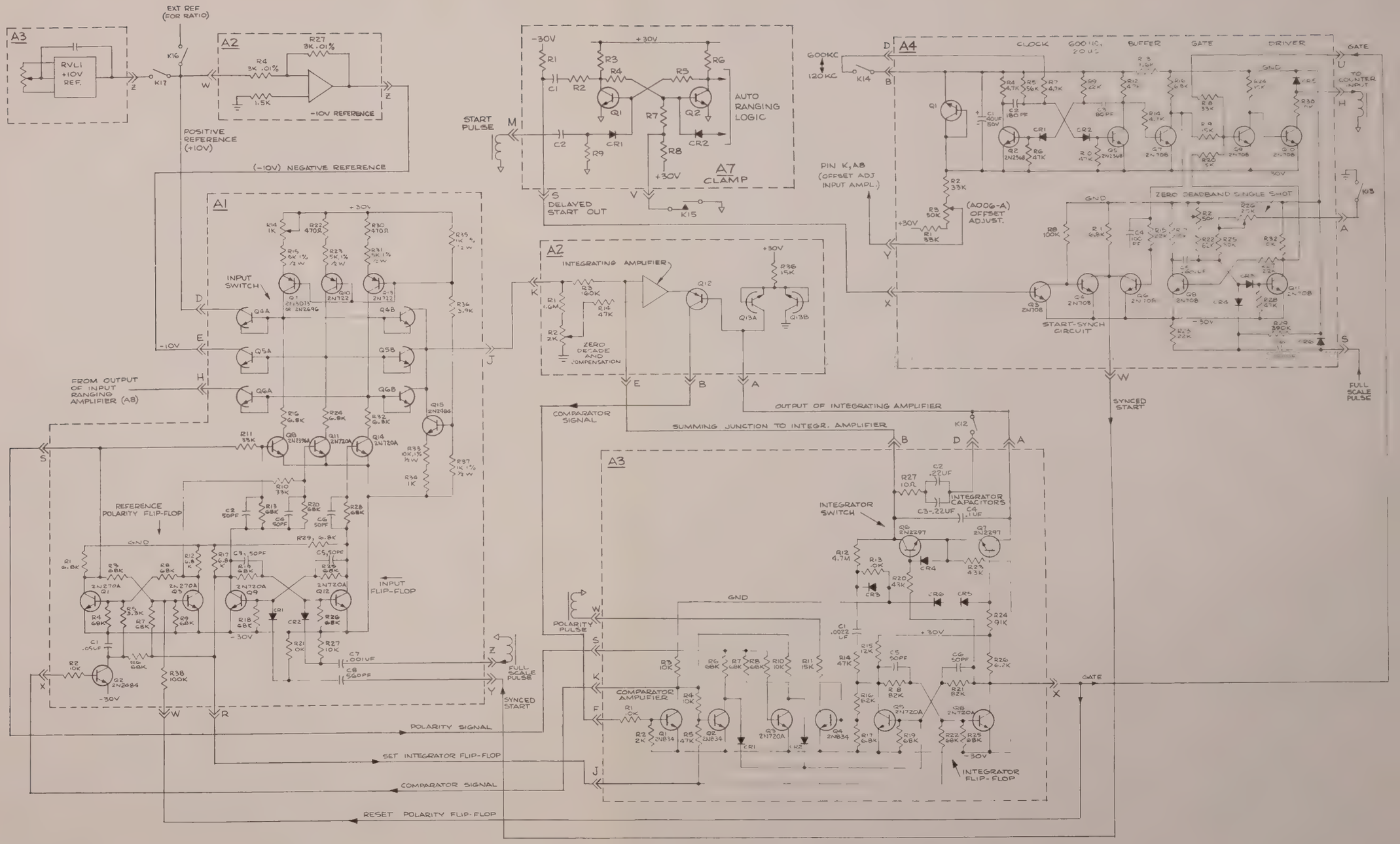


Figure 5-13 Measurement Circuit Simplified Schematic

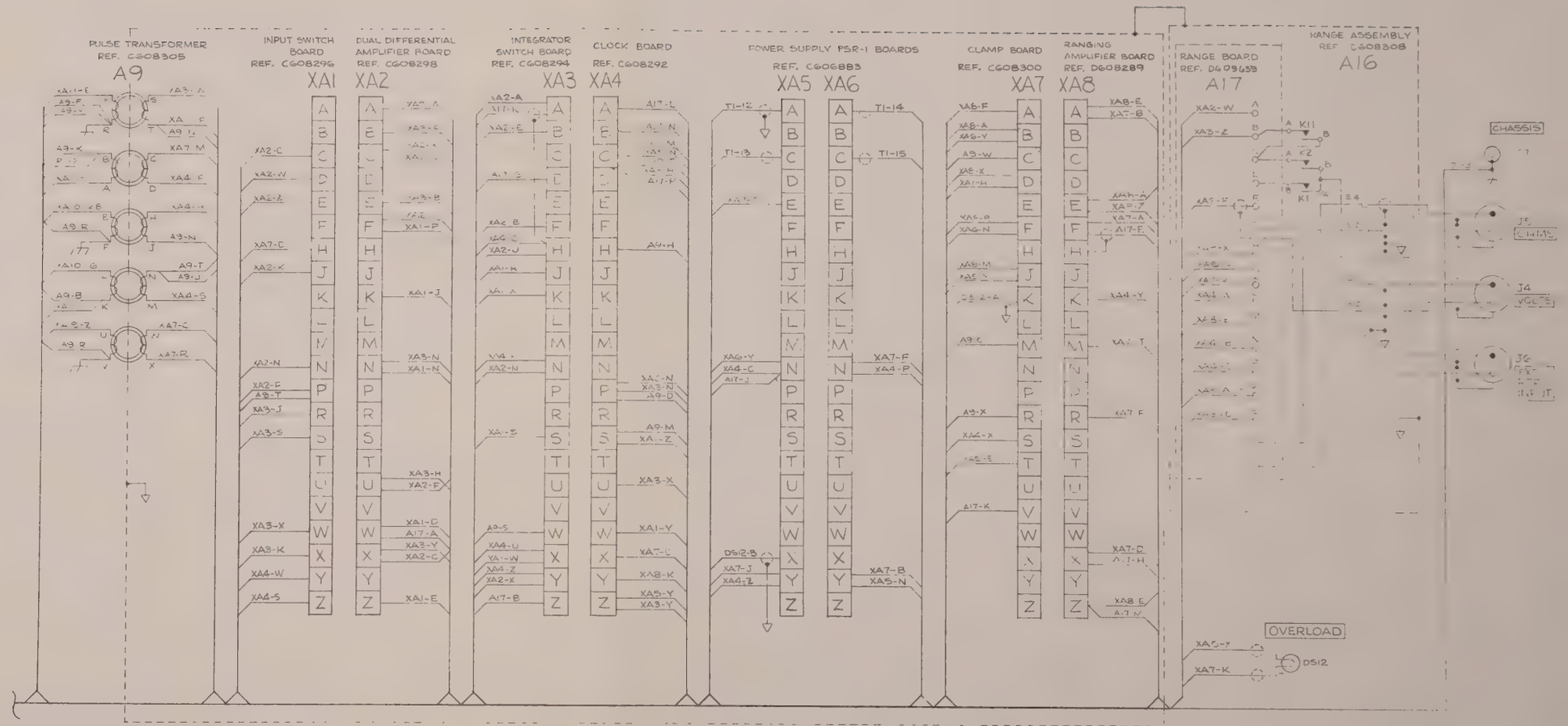


Figure 5-14 Model 7100 Wiring Diagram
(Sheet 1 of 2)

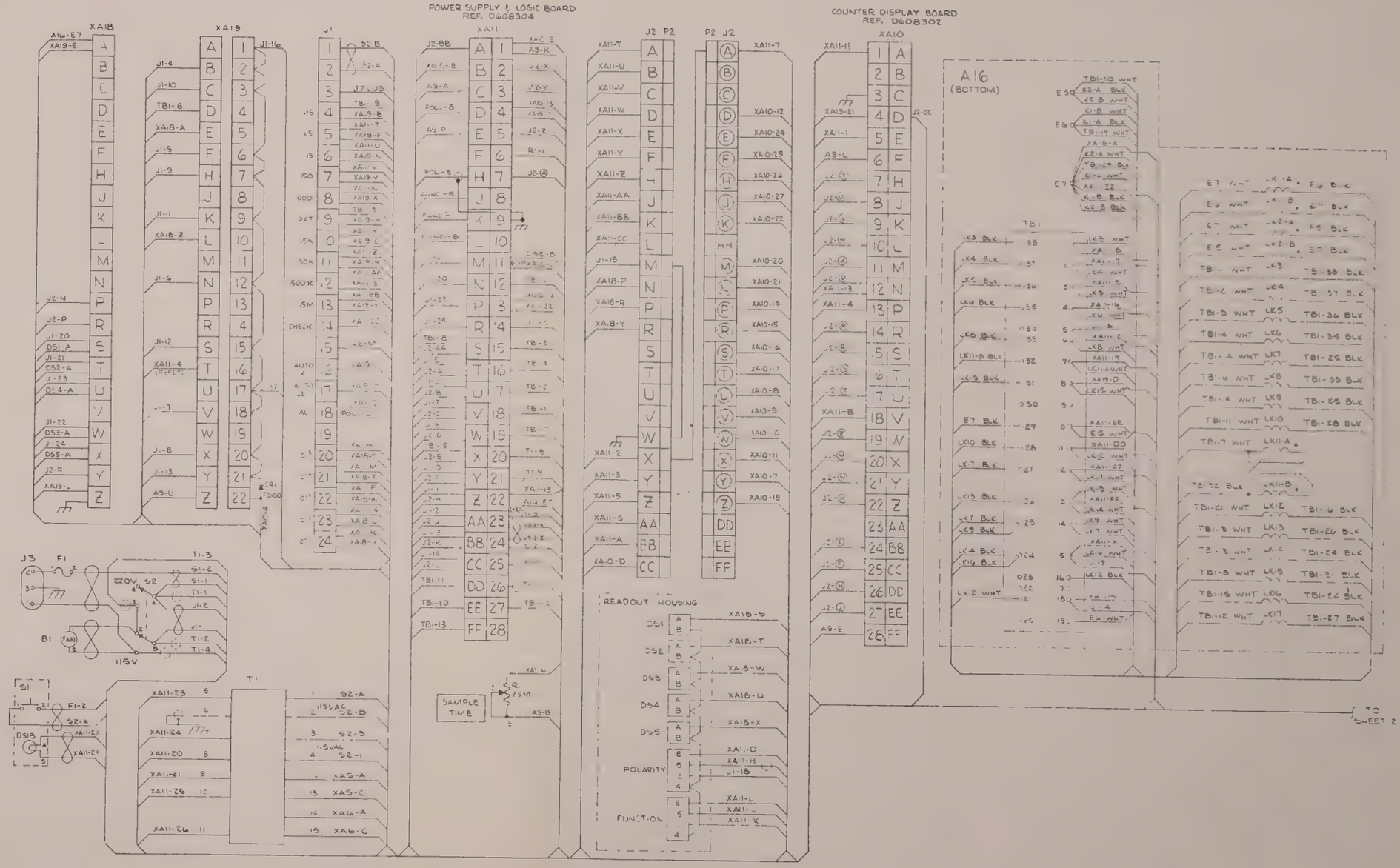
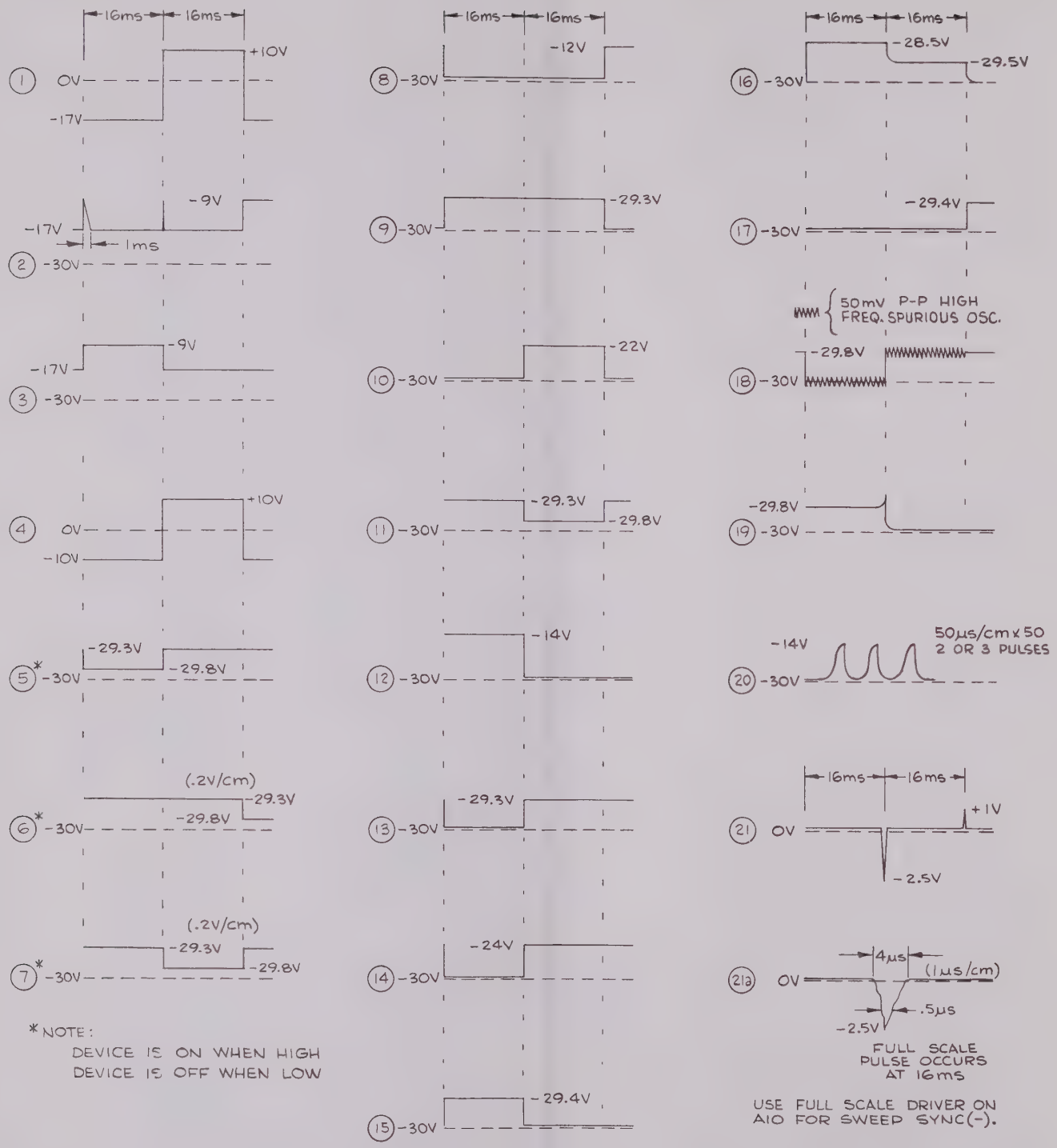


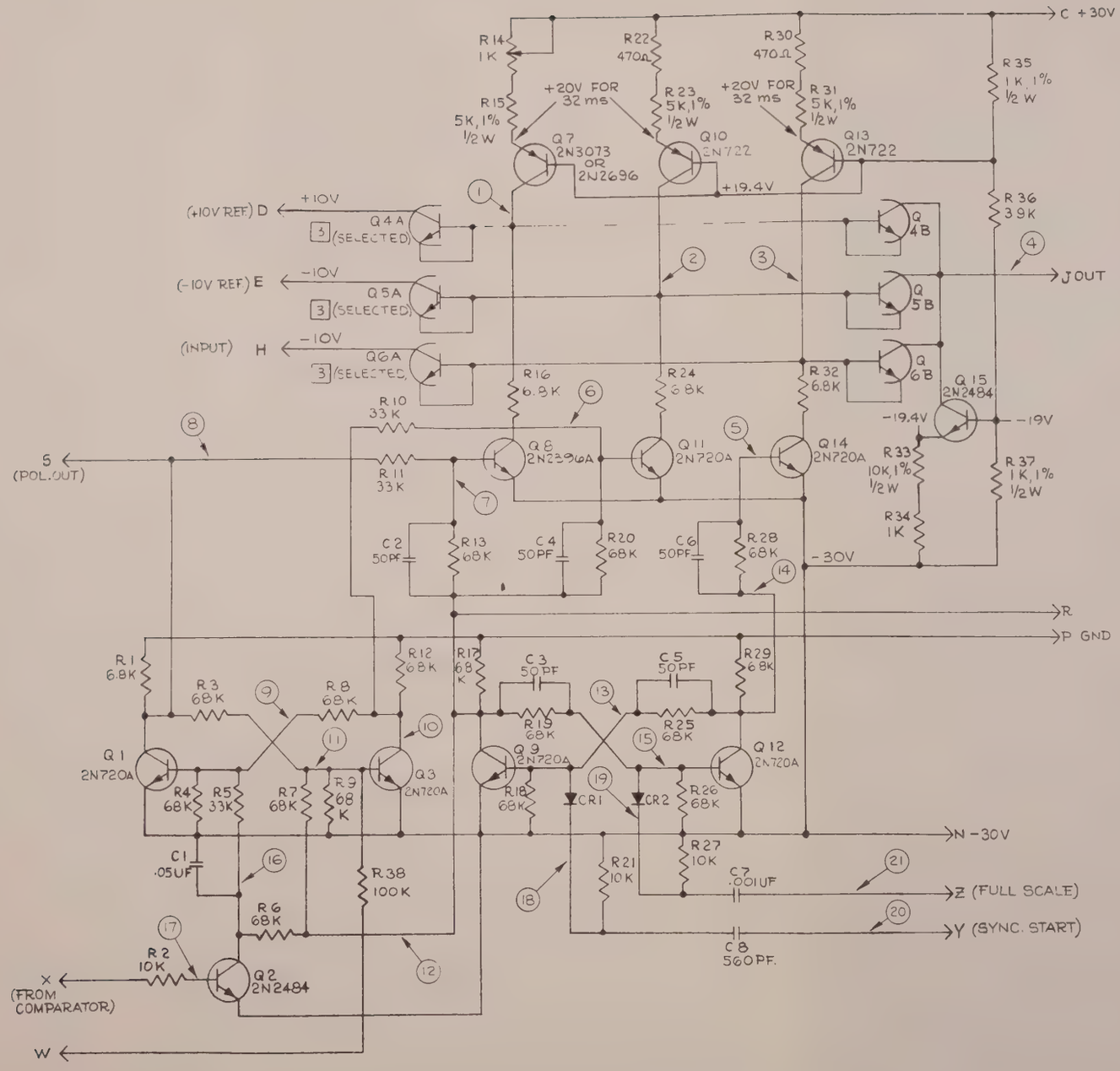
Figure 5-14 Model 7100 Wiring Diagram
(Sheet 2 of 2)



TEST CONDITIONS: SET FRONT PANEL FUNCTION/MODE SWITCH TO CHECK (E_{in} = +10.000 VOLTS DC). CONNECT GUARD TERMINAL ON VOLTS INPUT JACK TO FRONT PANEL CHASSIS CONNECTOR.

OSCILLOSCOPE SETTINGS: USE COLLECTOR OF Q9, BOARD A11 (RESET PULSE) FOR SWEEP SYNC (-), UNLESS OTHERWISE SPECIFIED. SET OSCILLOSCOPE SWEEP SPEED AND VERTICAL GAIN AS SHOWN IN DIAGRAMS.

Figure 5-15 Input Switch Board A1 Waveforms



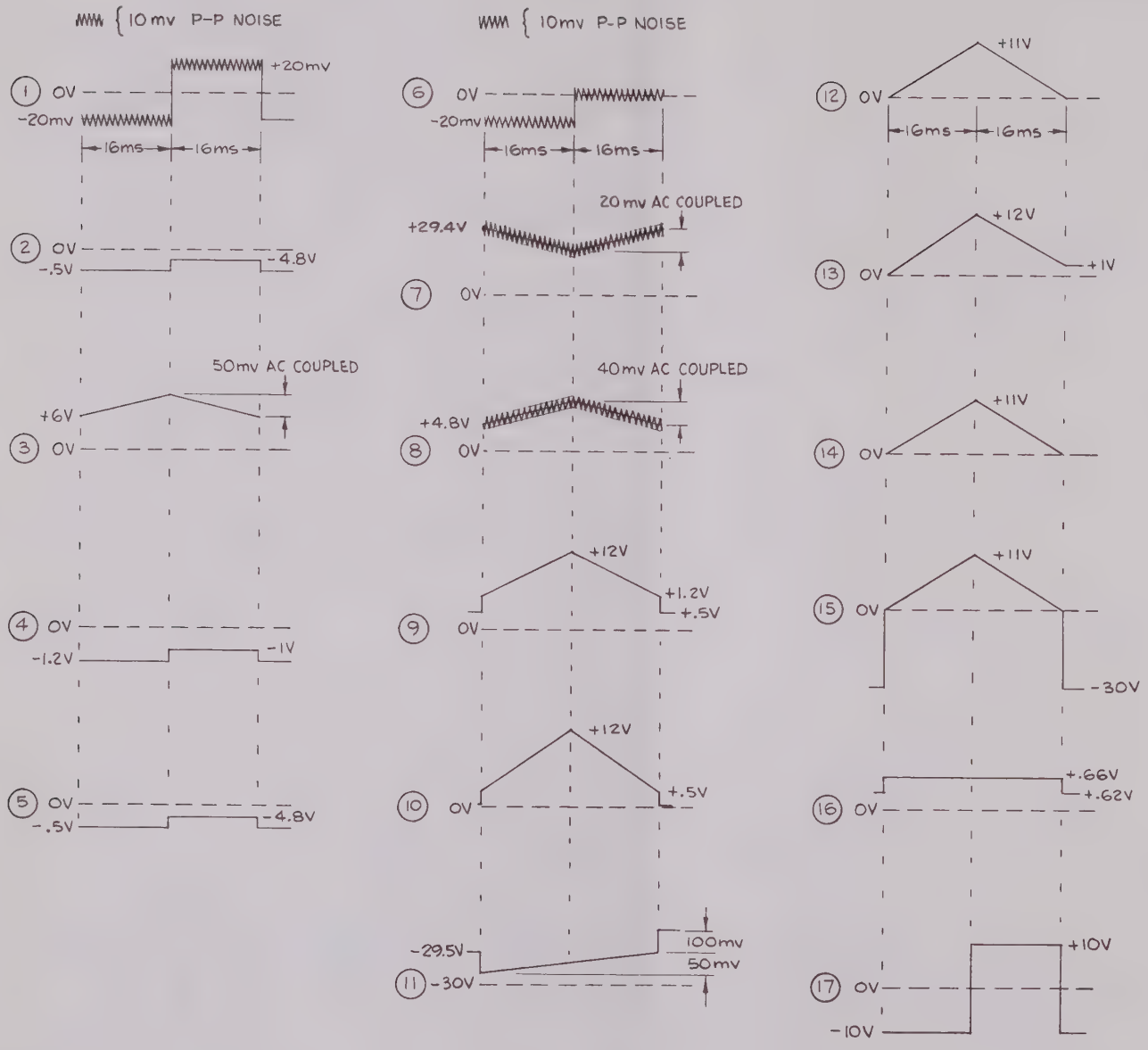
3 SEE DWG B900000

2. ALL DIODES FD120

1. ALL RESISTOR 1/2W, 5%

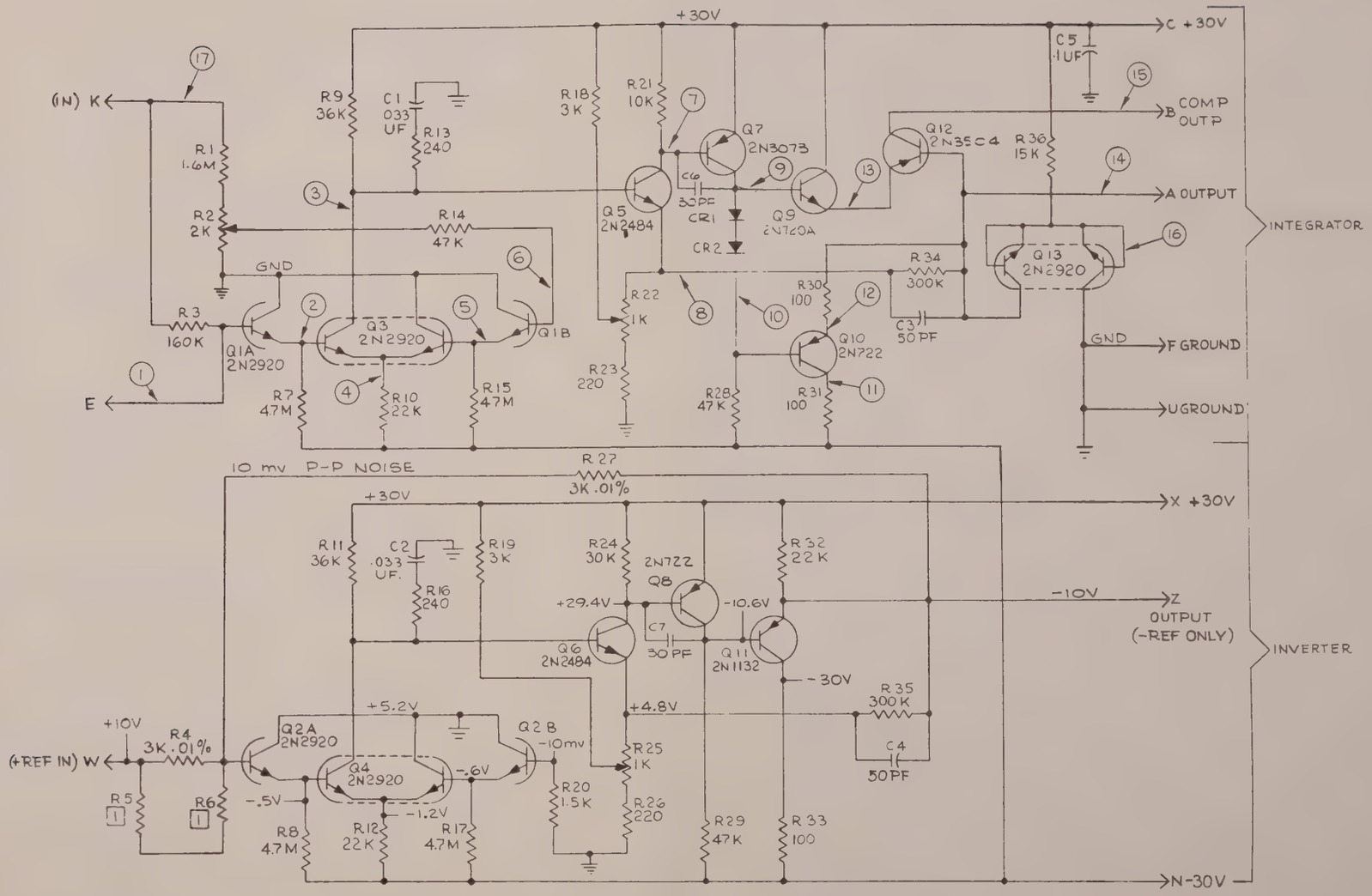
NOTES: UNLESS OTHERWISE SPECIFIED

Figure 5-16 Input Switch Board A1 Schematic



TEST CONDITIONS AND OSCILLOSCOPE SETTINGS: SAME AS FIGURE 5-15

Figure 5-17 Dual Differential Amplifier Board A2 Waveforms



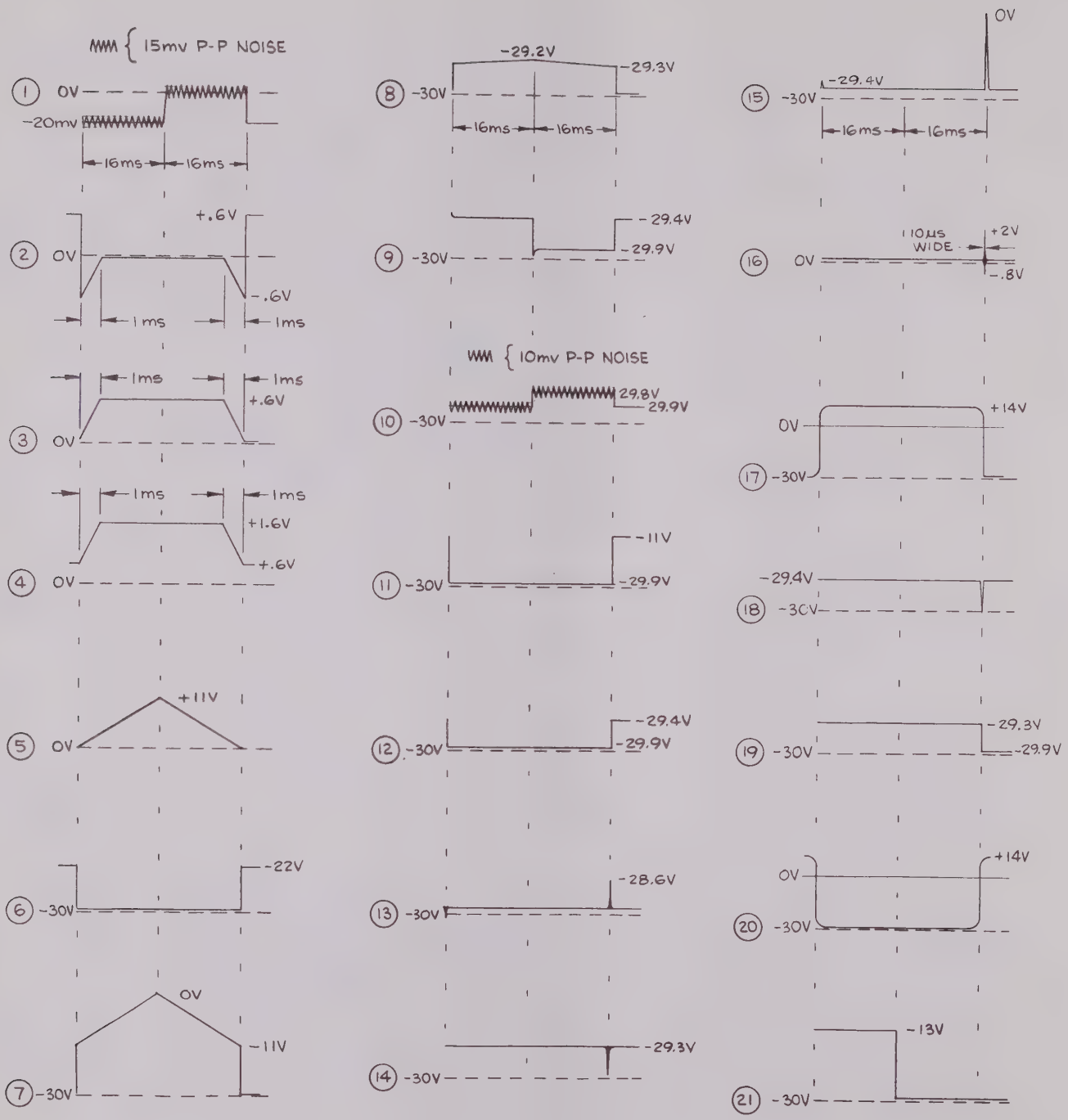
3. ALL RESISTOR ½ W, 5%

2. ALL DIODES FD100

[1] TRIM RESISTORS (22 MΩ TYPICAL)

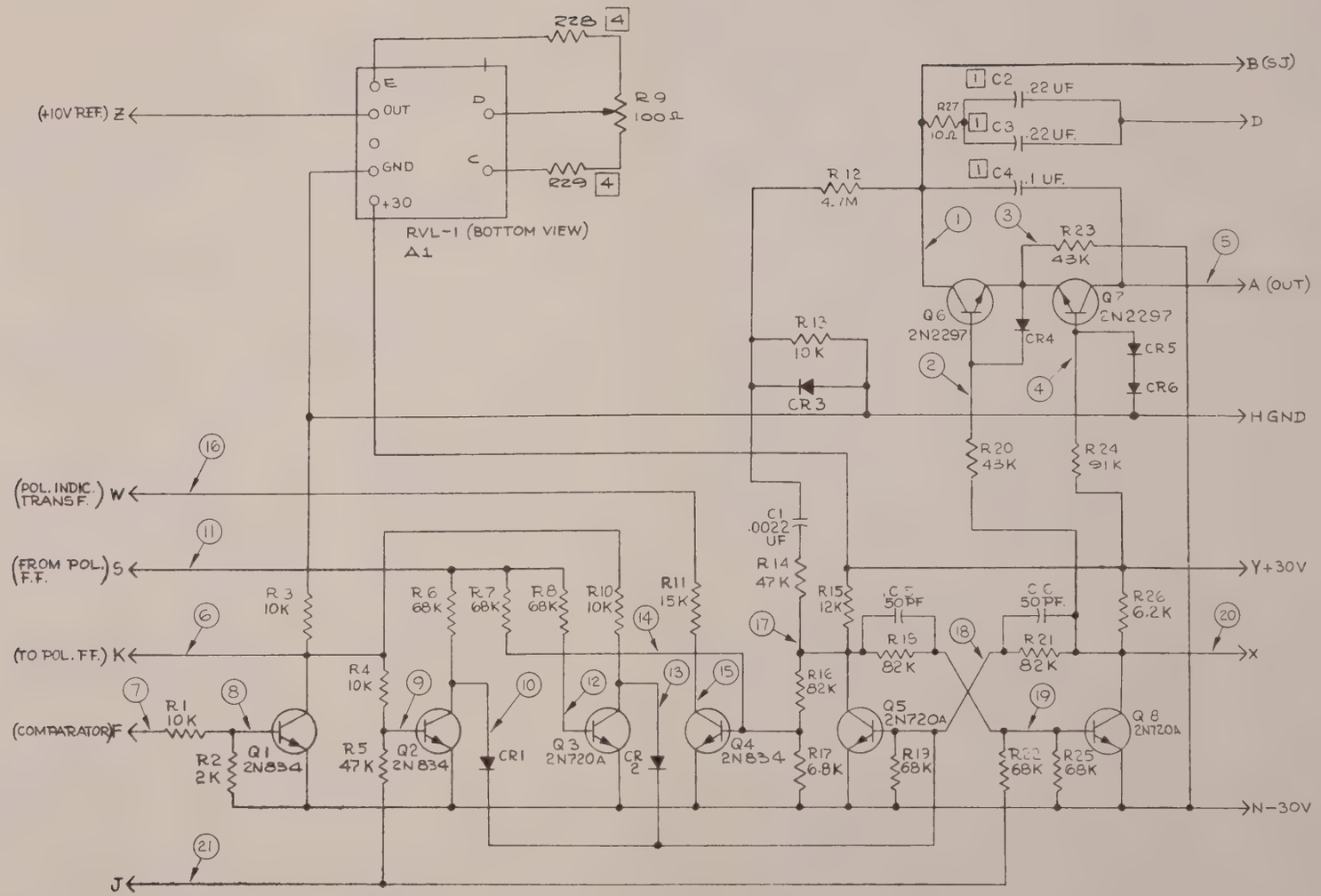
NOTES: UNLESS OTHERWISE SPECIFIED

Figure 5-18 Dual Differential Amplifier Board A2 Schematic



TEST CONDITIONS AND OSCILLOSCOPE SETTINGS: SAME AS FIGURE 5-15

Figure 5-19 Integrator Switch Board A3 Waveforms



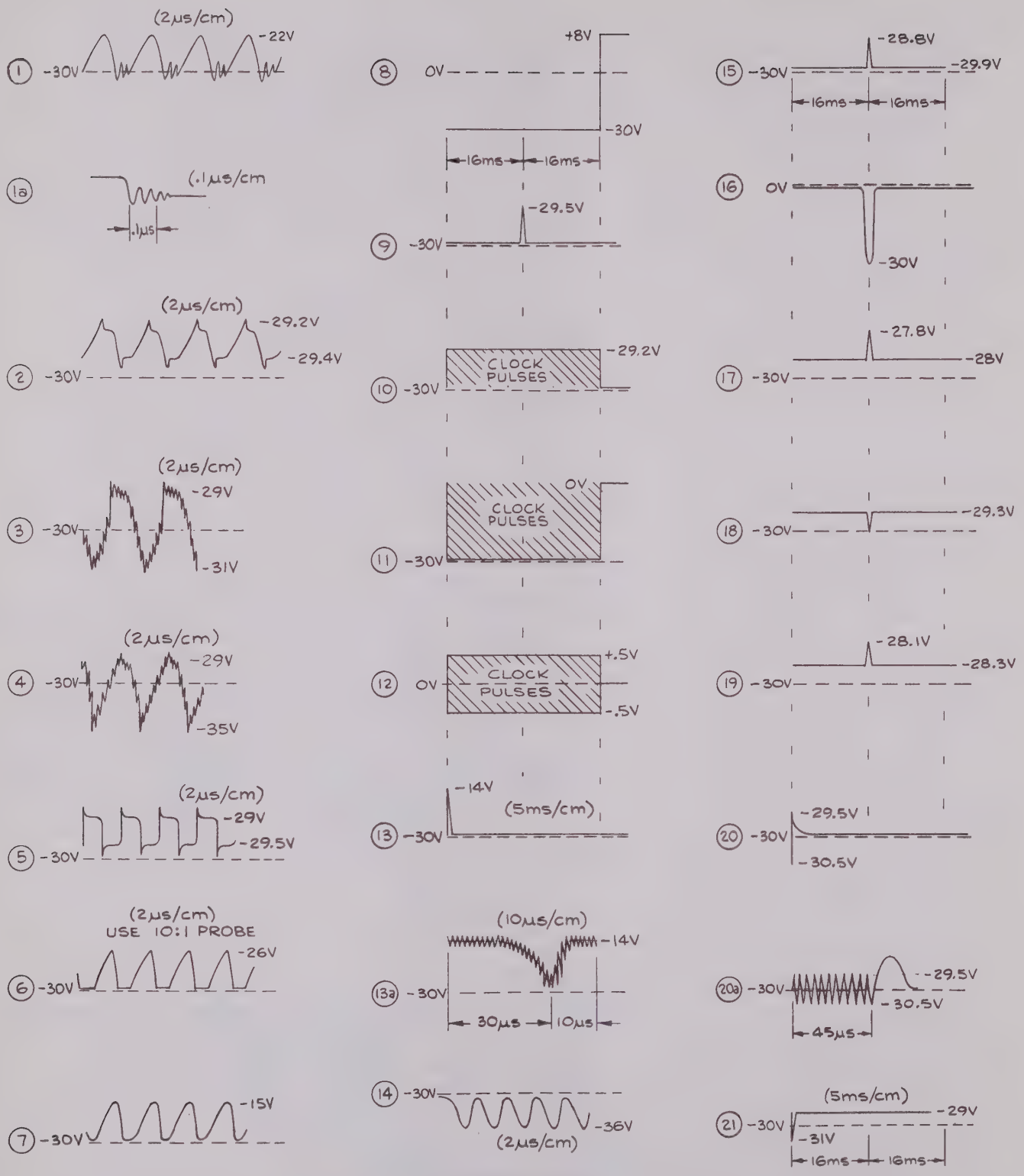
4 R28, R29 ½W, 1% METAL FILM SELECTED PER RVL-1 REQUIRMENTS.
VOUT (WITH PINS E&C SHORTED TO D ON RVL-1

VOUT RANGE	R28	R29
10.00 TO 9.89	200Ω	100Ω
9.89 TO 9.78	100Ω	200Ω
9.78 TO 9.70	51.1Ω	249Ω

3. ALL RESISTORS ½W 5%
2. ALL DIODES FD100
1 CAPACITORS GOODALL POLYSTRENE 100V 5%

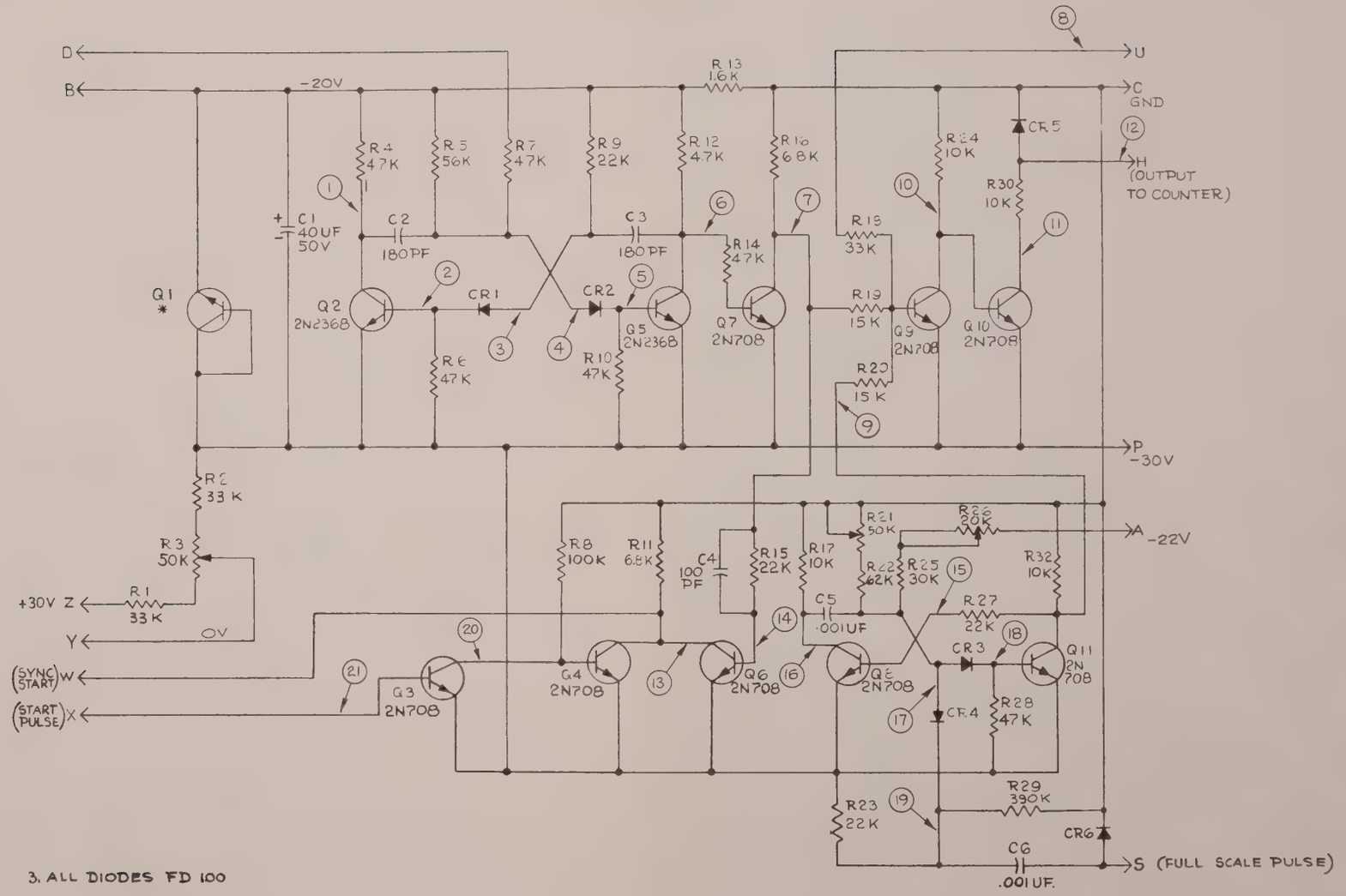
NOTES: UNLESS OTHERWISE SPECIFIED

Figure 5-20 Integrator Switch Board A3 Schematic



TEST CONDITIONS AND OSCILLOSCOPE SETTINGS: SAME AS FIGURE 5-15

Figure 5-21 Clock Board A4 Waveforms



3. ALL DIODES FD 100

2. * Q1 2N699 SELECTED BVECO 9.0 TO 11.0V AT 15 mA.

1. ALL RESISTOR 1/2 W, 5%

NOTES: UNLESS OTHERWISE SPECIFIED

Figure 5-22 Clock Board A4 Schematic

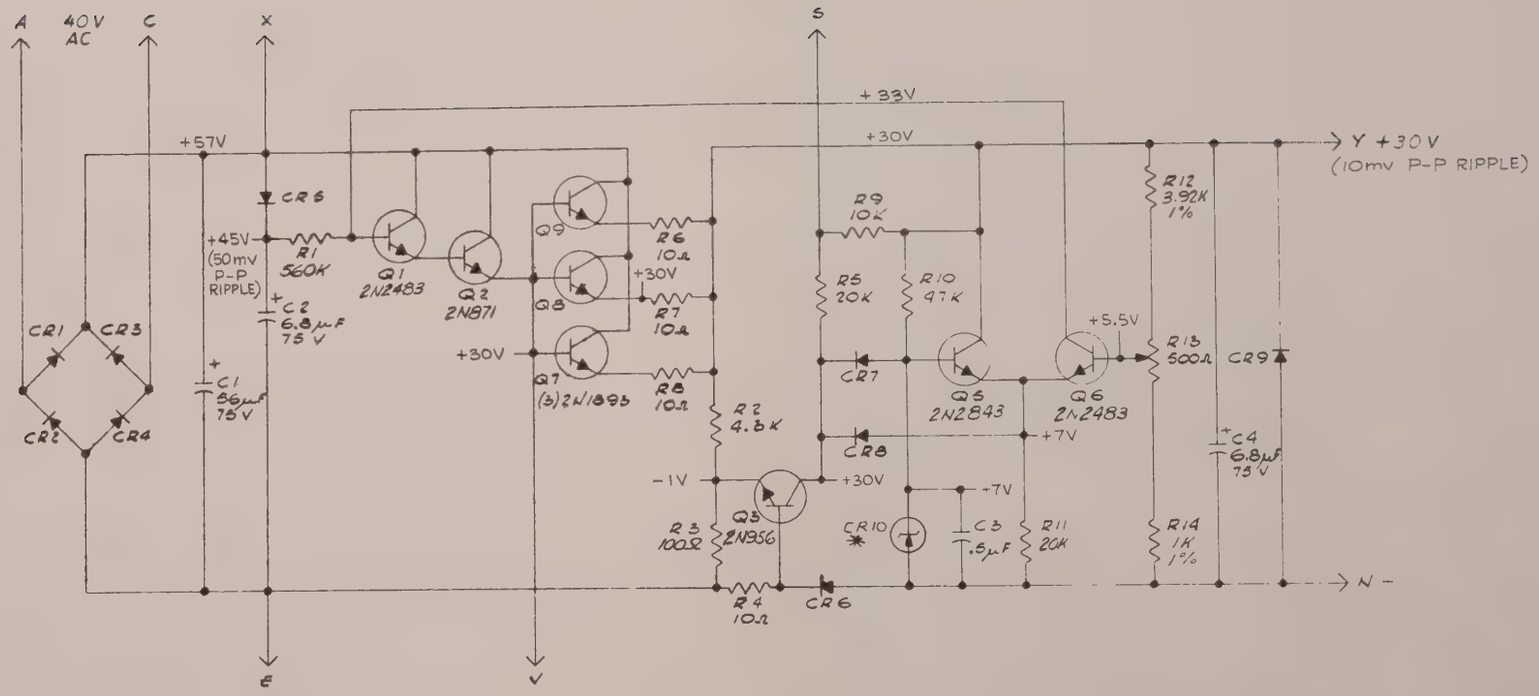
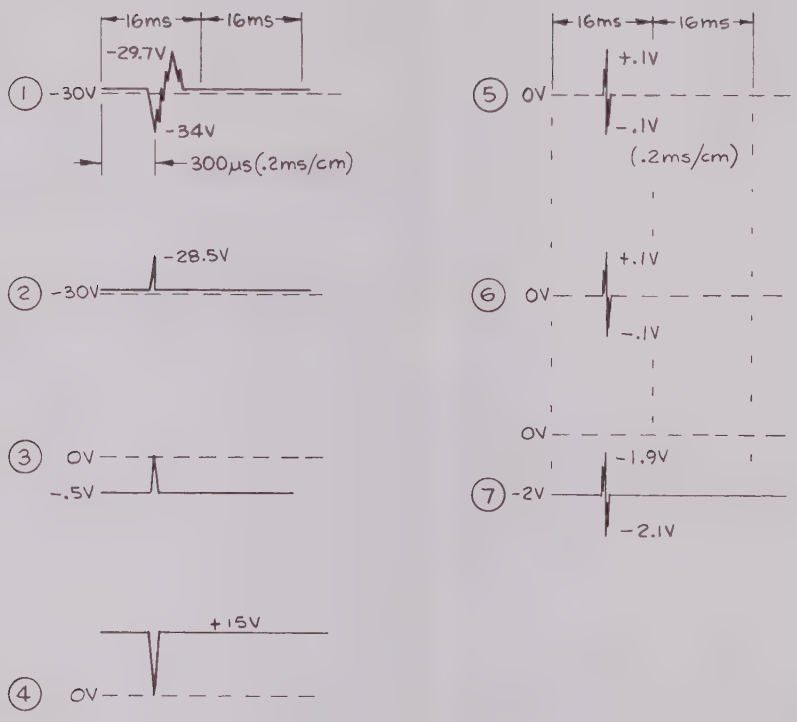


Figure 5-23 Power Supply PSR-1
Board A5, A6 Schematic



TEST CONDITIONS AND OSCILLOSCOPE SETTINGS: SAME AS FIGURE 5-15

Figure 5-24 Clamp Board A7 Waveforms

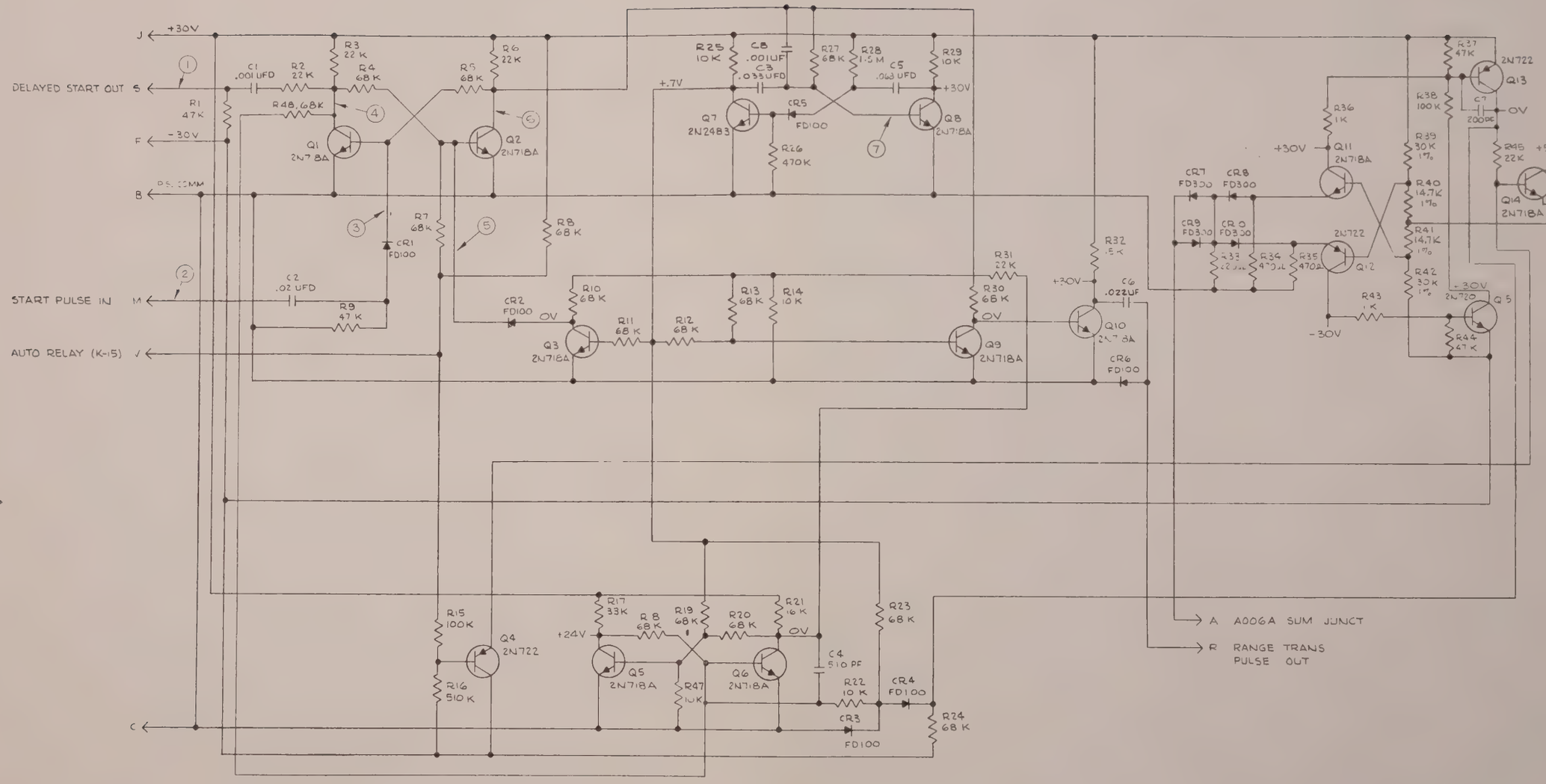
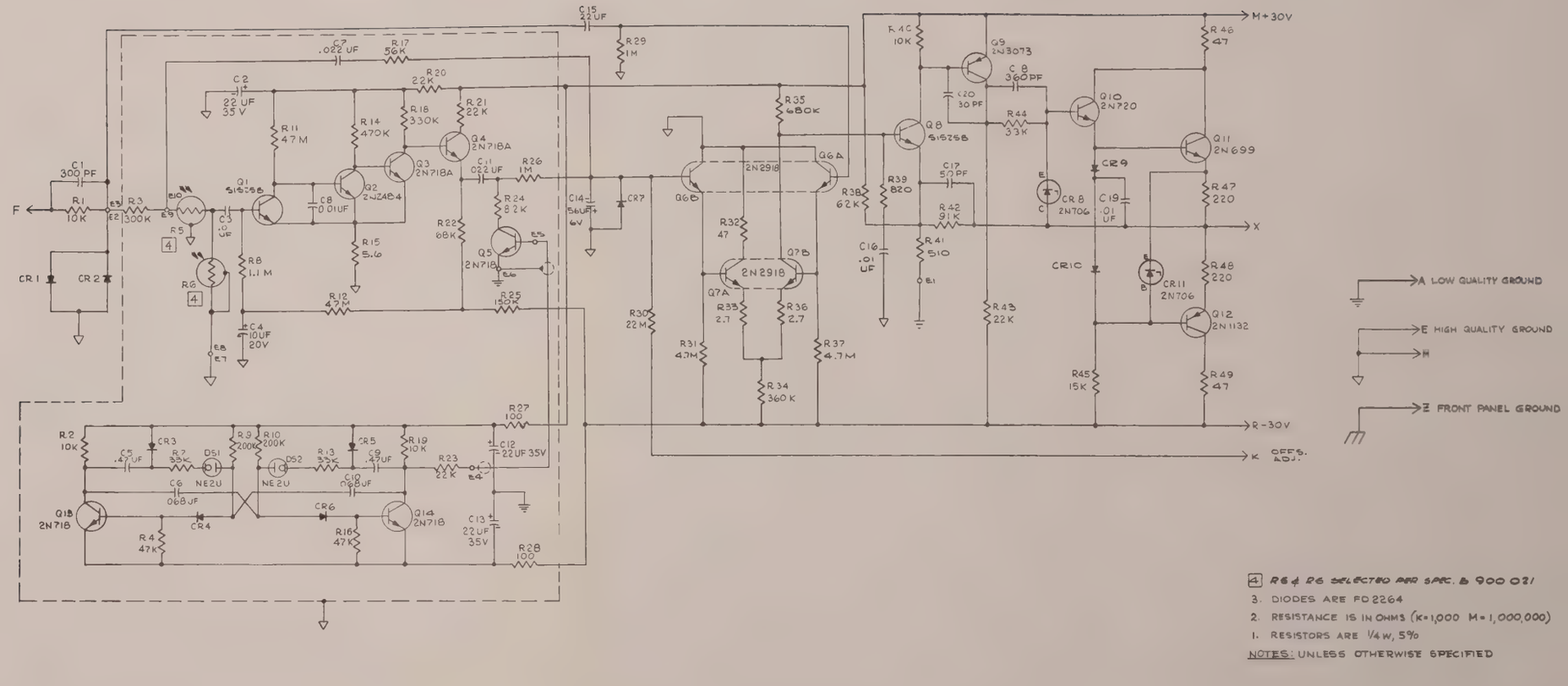
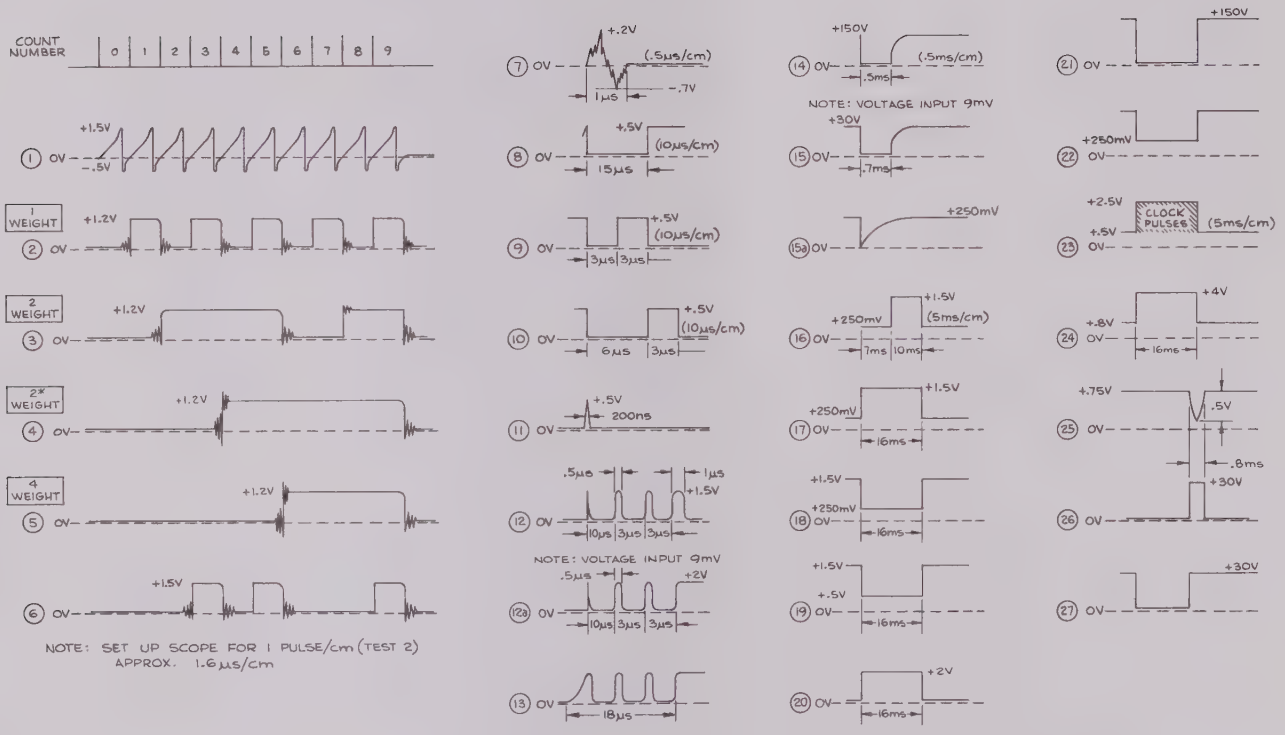


Figure 5-25 Clamp Board A7 Schematic



4 R6 & R8 SELECTED PER SPEC. B 900 021
3. DIODES ARE FD 2264
2. RESISTANCE IS IN OHMS (K=1,000 M=1,000,000)
1. RESISTORS ARE 1/4 W, 5%
NOTES: UNLESS OTHERWISE SPECIFIED

Figure 5-26 Amplifier Board A8 Schematic



TEST CONDITIONS: FOR WAVEFORMS 1 THROUGH 15 SET FUNCTION/MODE SWITCH TO 15 V AND CONNECT +10 MV DC TO VOLTS INPUT; FOR WAVEFORMS 16 THROUGH 27 SET FUNCTION/MODE SWITCH TO 1.5 V AND CONNECT +1 V DC TO VOLTS INPUT.

OSCILLOSCOPE SETTINGS: USE COLLECTOR OF Q11, BOARD A4 FOR OSCILLOSCOPE SYNC (-). SET SWEEP SPEED AND VERTICAL GAIN AS SHOWN IN DIAGRAMS.

Figure 5-27 Counter Display Board A10 Waveforms

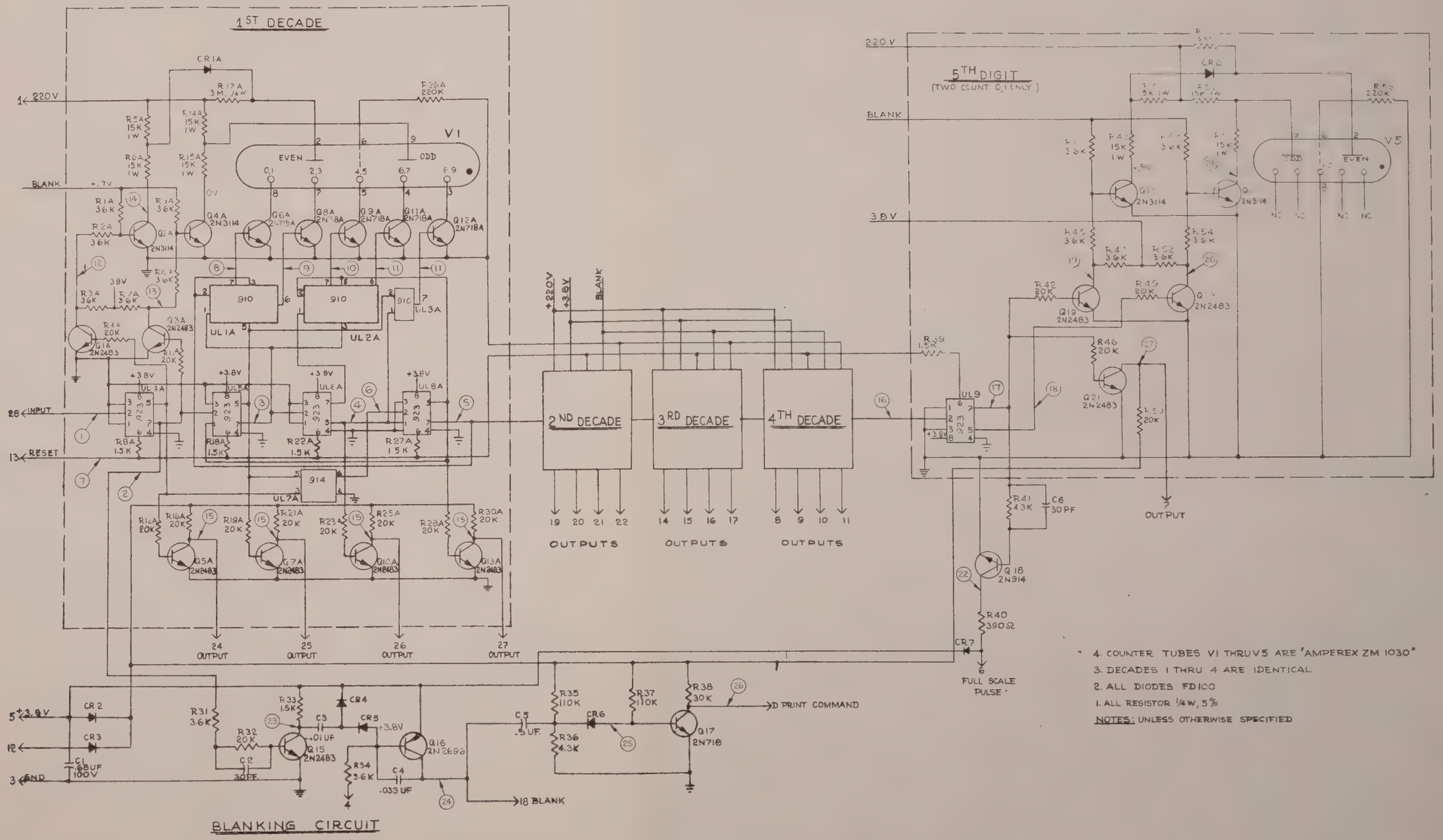
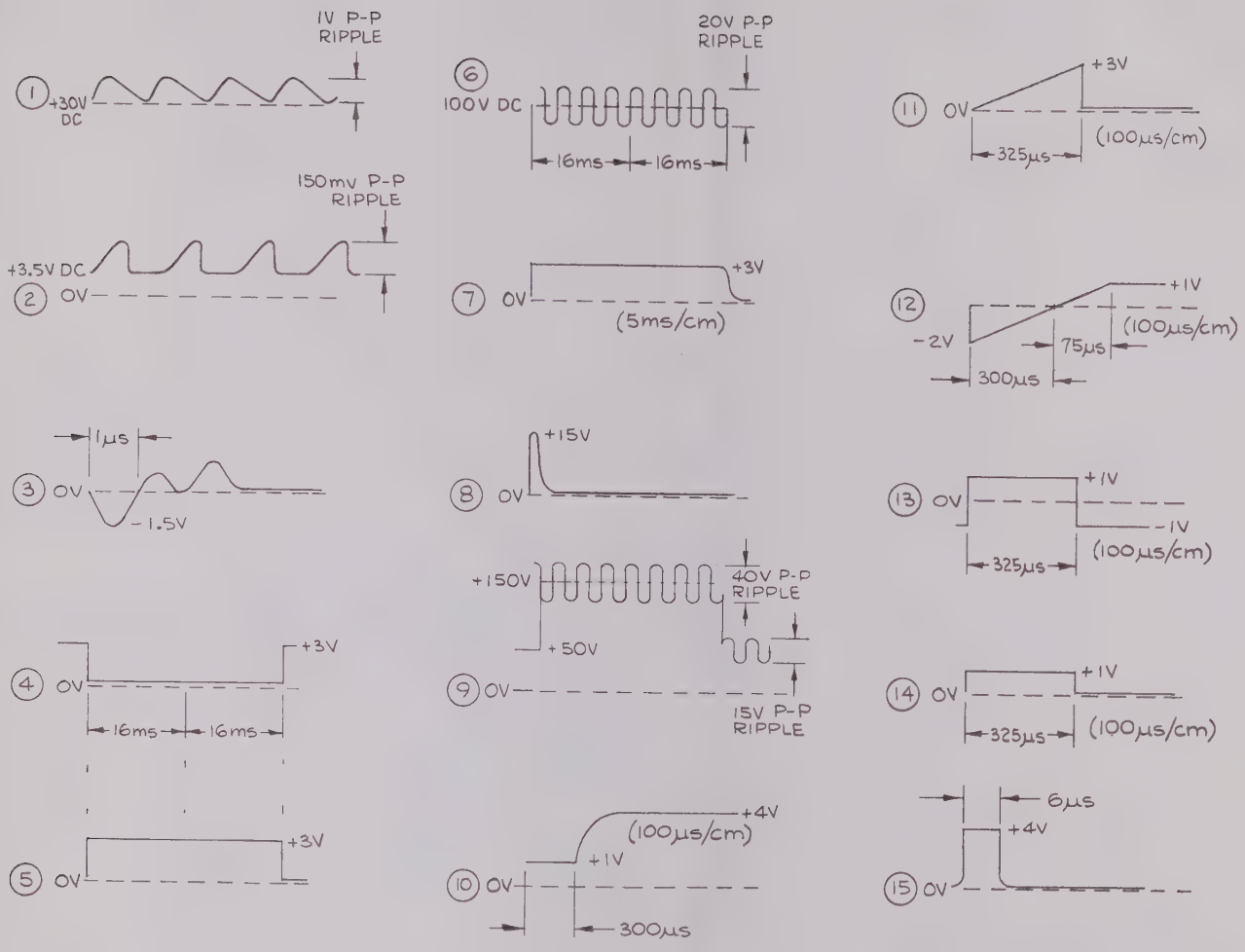


Figure 5-28 Counter Display Board A10 Schematic



TEST CONDITIONS AND OSCILLOSCOPE SETTINGS: SAME AS FIGURE 5-15

Figure 5-29 Power Supply and Logic Board All Waveforms

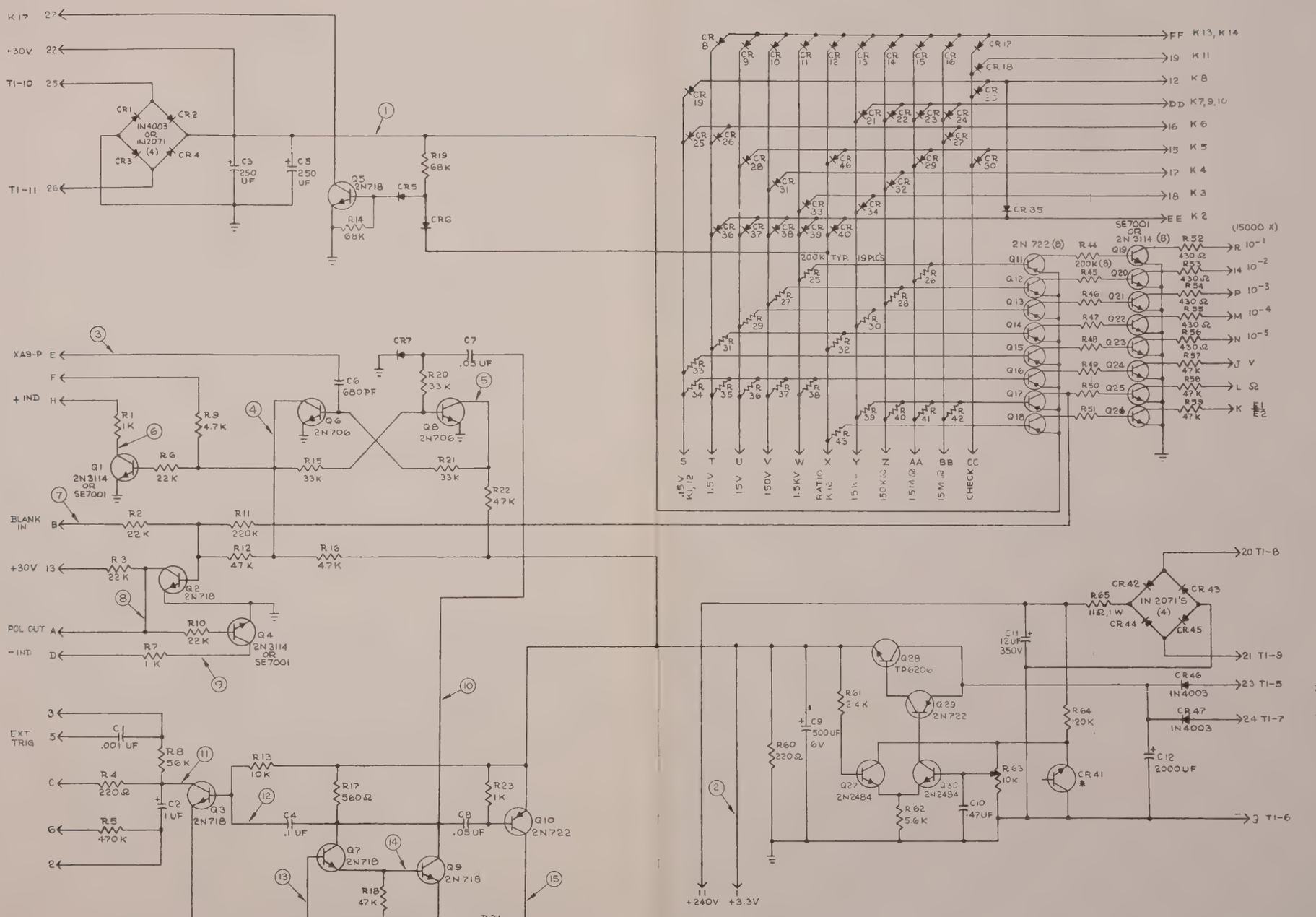


Figure 5-30 Power Supply and Logic Board A11 Schematic

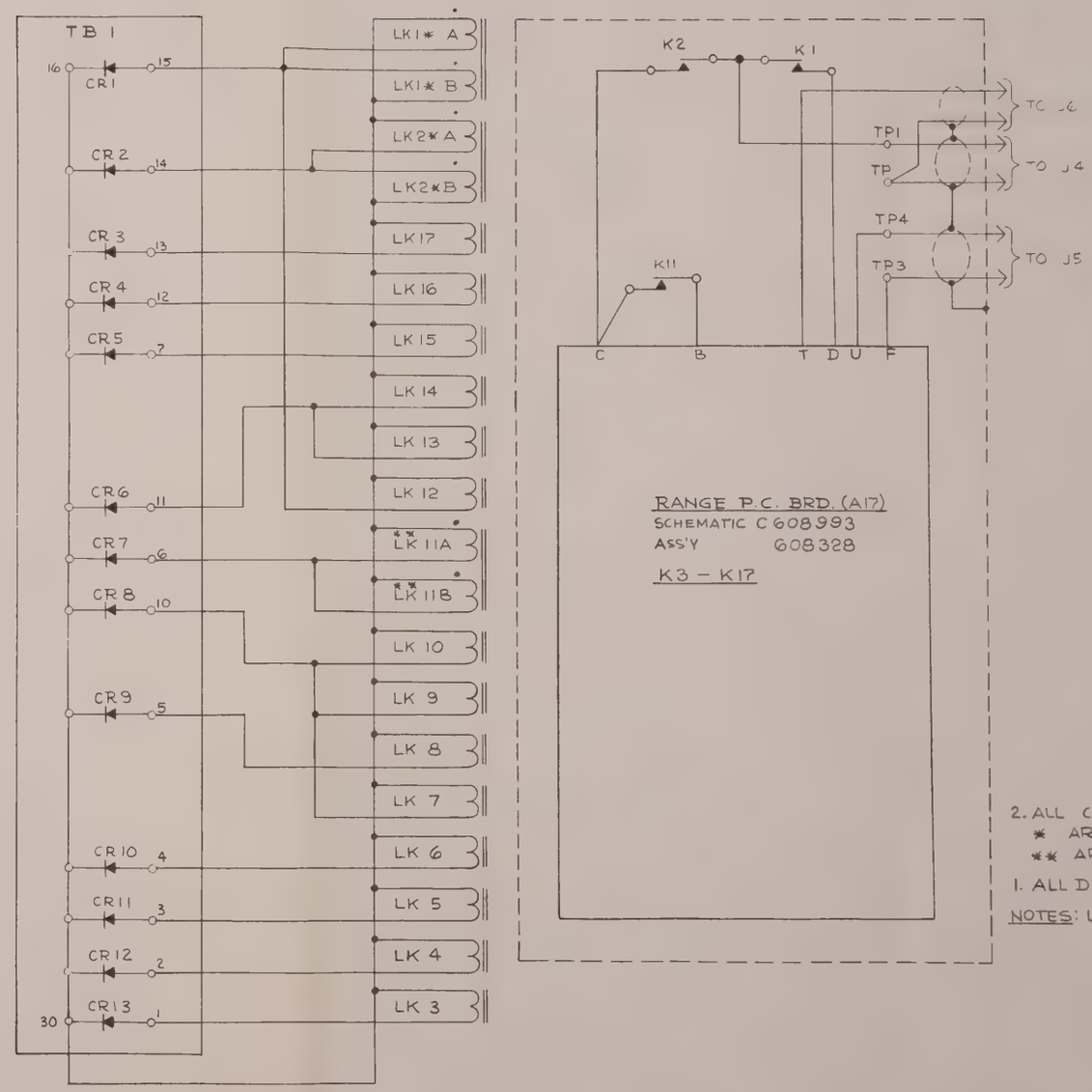


Figure 5-31 Range Assembly A16
Schematic

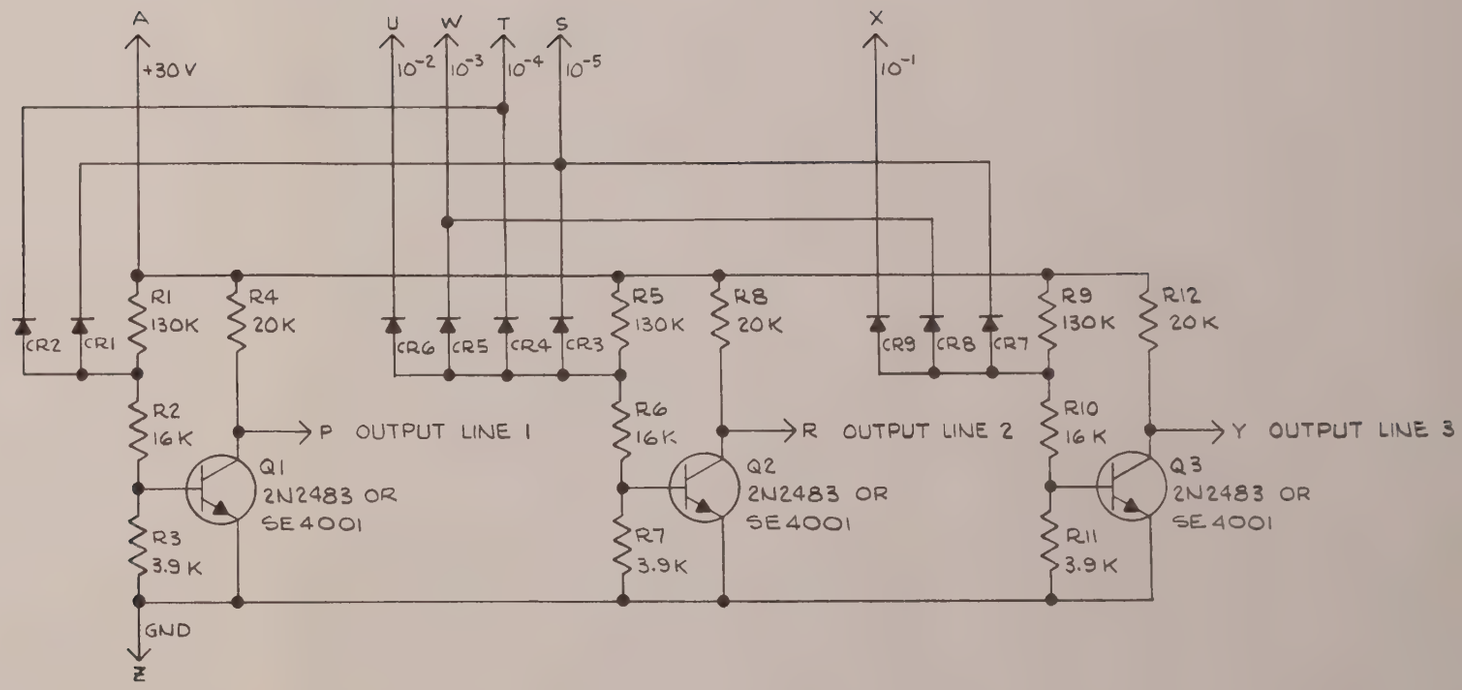
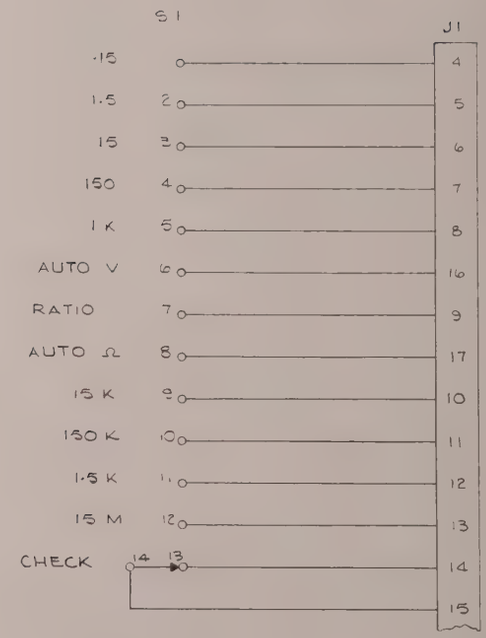


Figure 5-32 Decimal Point Encoder
Board A18 Schematic



REAR VIEW OF S1

Figure 5-33 DM-01A Plug-In Schematic

SECTION VI
REPLACEABLE PARTS

6-1. GENERAL

6-2. Tables 6-1 through 6-16 contain information for ordering replacement parts, listing: circuit reference; description; manufacturer; and Fairchild Instrumentation part number. Table 6-17 lists recommended spare parts and recommended spare circuit boards. This table constitutes the military recommended spare parts provisioning list for 1 to 3 years service in an isolated location. The spare circuit boards may be considered optional for commercial users. They are not necessary but are recommended to facilitate rapid isolation of a difficulty to a particular circuit board.

6-3. ORDERING INFORMATION

6-4. To order a replacement part, address order to your authorized Fairchild Instrumentation sales representative or to: 844 Charleston Ave., Palo Alto, California.

6-5. Specify the following information for each part:

a. Model and serial number of instrument.

b. Fairchild Instrumentation stock number.

c. Circuit reference designation and assembly number.

d. Complete description.

6-6. To order a part not listed in tables 6-1 through 6-17, provide a complete description of the part, including the function and location.

ABBREVIATIONS

Allen-Bradley	Allen-Bradley Co.	Good-All	Good All Mfg. Co.
Amperex	Amperex Electronic Corp.	Gordos	Gordos Corp.
Amphenol	Amphenol-Borg Electronics	Hopkins	Hopkins Engineering Co.
Arco	Arco Electronics, Inc.	Marco-Oak	Marco-Oak Industries
Beckman	Helipot Div., Beckman Inst. Inc.	Mepco	Mepco, Inc.
Cal.Std.Corp.	Calibration Standards, Corp.	Oak	Oak Mfg. Co.
Coto	Coto-Coil Co. Inc.	Ohmite	Ohmite Mfg. Co.
Cornel-Dubilier	Cornell-Dubilier Electronics	RBM Controls	RBM Controls Div. Essex Wire Corp.
CRL	Centralab Div. of Globe-Union, Inc.	Rotron	Rotron Mfg. Co.
Dale	Dale Electronics	Sprague	Sprague Electric Co.
Dialco	Dialight Corp.	Topaz	Topaz, Inc.
Elmenco	The Electro Motive Mfg. Co.	TRW	Thompson-Ramo-Woolridge
Fairchild	Fairchild Semiconductor Corp.	Vishay	Vishay Inst., Inc.
Fansteel	Fansteel Metalurgical Corp.	Welwyn	Welwyn International
General Electric	General Electric Co., Lamp Div.		

Table 6-1 Input Switch Board A1 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, .05 µf 50 v disc	Sprague	5301-24
C2	Capacitor, fixed, 50 pf DM-15	Arco	5300-59
C3	Same as C2		
C4	Same as C2		
C5	Same as C2		
C6	Same as C2		
C7	Capacitor, fixed, .001 µf disc	Cornell-Dublier	5301-15
C8	Capacitor, fixed, 560 pf DM-15	Arco	5300-87
CR1	Diode, FD100	Fairchild	5152-37
CR2	Same as CR1		
Q1	Transistor, 2N720A	Fairchild	5152-35
Q2	Transistor, 2N2484	Fairchild	5151-98
Q3	Same as Q1		
Q4	Transistor, 2N2920		5154-51
Q5	Same as Q4		
Q6	Same as Q4		
Q7	Transistor, 2N3073 or 2N2696		5154-16/ 5152-19
Q8	Same as Q1		
Q9	Same as Q1		
Q10	Transistor, 2N722	Fairchild	5152-73
Q11	Same as Q1		
Q12	Same as Q1		
Q13	Same as Q10		
Q14	Same as Q1		
Q15	Same as Q2		
R1	Resistor, fixed, 6.8K ±5% 1/2 w	Allen-Bradley	5215-72
R2	Resistor, fixed, 10K ±5% 1/2 w	Allen-Bradley	5215-76
R3	Resistor, fixed, 68K ±5% 1/2 w	Allen-Bradley	5215-97
R4	Same as R3		
R5	Resistor, fixed, 3.3K ±5% 1/2 w	Allen-Bradley	5215-64

Table 6-1 Input Switch Board A1 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R6	Same as R3		
R7	Same as R3		
R8	Same as R3		
R9	Same as R3		
R10	Resistor , fixed, 33K ±5% 1/2 w	Allen-Bradley	5215-89
R11	Same as R10		
R12	Same as R1		
R13	Same as R3		
R14	Resistor, variable, 1 K	Beckman	5291-67
R15	Resistor, fixed, 5K ±1% 1/2w		5210-78
R16	Same as R1		
R17	Same as R1		
R18	Same as R3		
R19	Same as R3		
R20	Same as R3		
R21	Same as R2		
R22	Resistor, fixed, 470 Ω ±5% 1/2 w	Allen-Bradley	5215-43
R23	Same as R15		
R24	Same as R1		
R25	Same as R3		
R26	Same as R3		
R27	Same as R2		
R28	Same as R3		
R29	Same as R1		
R30	Same as R22		
R31	Same as R15		
R32	Same as R1		
R33	Resistor, fixed 10K ±1% 1/2w		5210-88
R34	Resistor, fixed, 1 K ±5% 1/2 w	Allen-Bradley	5215-51
R35	Resistor, fixed 1K ±1% 1/2w		5210-58
R36	Resistor, fixed 3.9K ±5% 1/2 w	Allen-Bradley	5215-66
R37	Same as R35		
R38	Resistor, fixed 100K ±5% 1/2 w	Allen-Bradley	5216-02

Table 6-2 Dual Differential Amplifier Board A2 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, .033 µf 200 v 10%	TRW	5302-11
C2	Same as C1		
C3	Capacitor, fixed, 50 pf 300 v 5%	Arco	5300-59
C4	Same as C3		
C5	Capacitor, fixed, 0.1 µf 50 v 20%	Hopkins	5302-67
C6, C7	Capacitor, fixed, 30 pf 300 v 5%	Elmenco	5300-53
CR1	Diode, FD100	Fairchild	5151-37
CR2	Same as CR1		
Q1	Transistor, 2N2920	Fairchild	5154-06
Q2	Same as Q1		
Q3	Same as Q1		
Q4	Same as Q1		
Q5	Transistor, 2N2484	Fairchild	5151-98
Q6	Same as Q5		
Q7	Transistor, 2N3073	Fairchild	5154-16
Q8	Transistor, 2N722	Fairchild	5152-73
Q9	Transistor, 2N720A	Fairchild	5152-35
Q10	Same as Q8		
Q11	Transistor, 2N1132	Fairchild	5151-39
Q12	Transistor, 2N3504	Fairchild	5154-18
Q13	Same as Q1		
R1	Resistor, fixed, 1.6M ±5% 1/2 w	Allen-Bradley	5216-33
R2	Resistor, variable, 2K	Beckman	5291-97
R3	Resistor, fixed, 160K ±5% 1/2 w	Allen-Bradley	5216-08
R4	Resistor, fixed, 3K ±.01% 1/2 w	Vishay	5219-74
R5	Resistor, fixed, 22M ±5% 1/2 w	Allen-Bradley	5216-61
R6	Same as R5		
R7	Resistor, fixed, 4.7 M ±5% 1/2 w	Allen-Bradley	5216-44
R8	Same as R7		
R9	Resistor, fixed, 36K ±5% 1/2 w	Allen-Bradley	5215-90

Table 6-2 Dual Differential Amplifier Board A2 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R10	Resistor, fixed, 22K ±5% 1/2 w	Allen-Bradley	5215-85
R11	Same as R9		
R12	Same as R10		
R13	Resistor, fixed, 240Ω ±5% 1/2 w	Allen-Bradley	5215-36
R14	Resistor, fixed, 47K ±5% 1/2 w	Allen-Bradley	5215-93
R15	Same as R7		
R16	Same as R13		
R17	Same as R7		
R18	Resistor, fixed, 3K ±5% 1/2 w	Allen-Bradley	5215-63
R19	Same as R18		
R20	Resistor, fixed, 1.5K ±5% 1/2 w	Allen-Bradley	5215-56
R21	Resistor, fixed, 30K ±5% 1/2 w	Allen-Bradley	5215-88
R22	Resistor, variable,	Beckman	5291-67
R23	Resistor, fixed, 220Ω ±5% 1/2 w	Allen-Bradley	5215-35
R24	Same as R21		
R25	Same as R22		
R26	Same as R23		
R27	Same as R4		
R28	Same as R14		
R29	Same as R14		
R30	Resistor, fixed, 100Ω ±5% 1/2 w	Allen-Bradley	5215-26
R31	Same as R30		
R32	Same as R10		
R33	Same as R30		
R34	Resistor, fixed, 300K ±5% 1/2 w	Allen-Bradley	5216-14
R35	Same as R34		
R36	Resistor, fixed, 15K ±5% 1/2 w	Allen-Bradley	5215-81

Table 6-3 Integrator Switch Board A3 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, .0022 µf 200 v 20%	TRW	5302-03
C2	Capacitor, fixed, .22 µf 100 v 5%	Goodall	5303-30
C3	Same as C2		
C4	Capacitor, fixed, .1µf 100 v 5%	Goodall	5303-39
C5	Capacitor, fixed, 50 pf 300 v 5%	Elmenco	5300-59
C6	Same as C5		
CR1	Diode, FD100	Fairchild	5151-37
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Same as CR1		
Q1	Transistor, 2N834	Fairchild	5152-59
Q2	Same as Q1		
Q3	Transistor, 2N720A	Fairchild	5152-35
Q4	Same as Q1		
Q5	Same as Q3		
Q6	Transistor, 2N2297	Fairchild	5151-21
Q7	Same as Q6		
Q8	Same as Q3		
R1	Resistor, fixed, 10K ±5% 1/2 w	Allen-Bradley	5215-76
R2	Resistor, fixed, 2K ±5% 1/2 w	Allen-Bradley	5215-59
R3	Same as R1		
R4	Same as R1		
R5	Resistor, fixed, 47K ±5% 1/2 w	Allen-Bradley	5215-93
R6	Resistor, fixed, 68K ±5% 1/2 w	Allen-Bradley	5215-97
R7	Same as R6		
R8	Same as R6		
R9	Resistor, variable, 500Ω 1.5 w	Beckman	5291-66
R10	Same as R1		

Table 6-3 Integrator Switch Board A3 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R11	Resistor, fixed, 15K ±5% 1/2 w	Allen-Bradley	5215-81
R12	Resistor, fixed, 4.7M ±5% 1/2 w	Allen-Bradley	5616-44
R13	Same as R1		
R14	Same as R5		
R15	Resistor, fixed, 12K ±5% 1/2 w	Allen-Bradley	5215-78
R16	Resistor, fixed, 82K ±5% 1/2 w	Allen-Bradley	5215-99
R17	Resistor, fixed, 6.8K ±5% 1/2 w	Allen-Bradley	5215-72
R18	Same as R16		
R19	Same as R6		
R20	Resistor, fixed, 43 K ±5%, 1/2 w	Allen-Bradley	5215-92
R21	Same as R16		
R22	Same as R6		
R23	Same as R20		
R24	Resistor, fixed, 91K ±5%, 1/2 w	Allen-Bradley	5216-01
R25	Same as R6		
R26	Resistor, fixed, 6.2K ±5% 1/2 w	Allen-Bradley	5215-71
R27, R28	Resistor, fixed, selected according to RVL-1 requirements, see figure 5-20.		
RVL-1	Voltage, Reference, RVL-1	Fairchild	6905-22

Table 6-4 Clock Board A4 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, 40 µf, 50 v	Cornell-Dublier	5300-29
C2	Capacitor, fixed, 180 pf DM-15	Arco	5300-73
C3	Same as C2		
C4	Capacitor, fixed, 100 pf DM-15	Arco	5300-67
C5	Capacitor, fixed, .001 µf Mylar	Goodall	5302-01
C6	Capacitor, fixed, .001 µf Disc	Goodall	5301-15
CR1	Diode, FD100	Fairchild	5152-37
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Same as CR1		
Q1	Transistor, 2N699 , Selected	Fairchild	5154-02
Q2	Transistor, 2N2368	Fairchild	5154-04
Q3	Transistor, 2N708	Fairchild	5151-36
Q4	Same as Q3		
Q5	Same as Q2		
Q6	Same as Q3		
Q7	Same as Q3		
Q8	Same as Q3		
Q9	Same as Q3		
Q10	Same as Q3		
Q11	Same as Q3		
R1	Resistor, fixed, 33 K ±5% 1/2 w	Allen-Bradley	5215-89
R2	Same as R1		
R3	Resistor, variable, 50K	Beckman	
R4	Resistor, fixed,4.7K ±5% 1/2 w	Allen-Bradley	5215-68
R5	Resistor, fixed 56K ±5% 1/2 w	Allen-Bradley	5215-95
R6	Resistor, fixed, 47K ±5% 1/2 w	Allen-Bradley	5215-93

Table 6-4 Clock Board A4 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R7	Same as R4		
R8	Resistor, fixed, 100K ±5% 1/2 w	Allen-Bradley	5216-02
R9	Resistor, fixed, 22K ±5% 1/2 w	Allen-Bradley	5215-85
R10	Same as R6		
R11	Resistor, fixed, 6.8K ±5% 1/2 w	Allen-Bradley	5215-72
R12	Same as R4		
R13	Resistor, fixed, 1.6K ±5% 1/2 w	Allen-Bradley	5215-57
R14	Same as R4		
R15	Same as R9		
R16	Same as R11		
R17	Resistor, fixed, 10K ±5% 1/2 w	Allen-Bradley	5215-76
R18	Same as R1		
R19	Resistor, fixed, 15K ±5% 1/2 w	Allen-Bradley	5215-81
R20	Same as R19		
R21	Resistor, variable	Beckman	5290-64
R22	Resistor, fixed, 62K ±5%, 1/2 w	Allen-Bradley	5215-96
R23	Same as R9		
R24	Same as R17		
R25	Resistor, fixed, 30K ±5% 1/2 w	Allen-Bradley	5215-88
R26	Resistor, variable, 20K	Beckman	5290-59
R27	Same as R9		
R28	Same as R6		
R29	Resistor, fixed, 390K ±5% 1/2 w	Allen-Bradley	5216-17
R30	Same as R17		
R31	Not assigned		
R32	Same as R17		

Table 6-5 Power Supply PSR-1 Boards A5 and A6 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, 56 µf 75 v, Tant	Semcor	5303-56
C2	Capacitor, fixed, 6.8 µf 75 v, Tant	Semcor	5303-55
C3	Capacitor, fixed, .5 µf, 50 v, Paper	Hopkins	5302-69
C4	Same as C2		
CR1	Diode, FD300	Fairchild	5152-08
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Same as CR1		
CR8	Same as CR1		
CR9	Same as CR1		
CR10	Diode, Zener - selected		A606982
Q1	Transistor, FT2483	Fairchild	5151-97
Q2	Transistor, 2N871	Fairchild	
Q3	Transistor, 2N956	Fairchild	
Q4	Not assigned		
Q5	Same as Q1		
Q6	Same as Q1		
Q7	Transistor, 2N1893	Fairchild	5151-92
Q8	Same as Q7		
Q9	Same as Q7		
R1	Resistor, fixed, 560 k ±5% 1/2 w		5216-21
R2	Resistor, fixed, 4.3 k ±5% 1/2 w		5215-67
R3	Resistor, fixed, 100 Ω ±5% 1/2 w		5215-26
R4	Resistor, fixed, 10 Ω ±5% 1/2 w		5215-01
R5	Resistor, fixed, 20 k ±5% 1/2 w		5215-84
R6	Same as R4		
R7	Same as R4		

Table 6-5 Power Supply PSR-1 Boards A5 and A6 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R8	Same as R4		
R9	Resistor, fixed, 10 k ±5% 1/2 w		5215-76
R10	Resistor, fixed, 47 k ±5% 1/2 w		5215-93
R11	Same as R5		
R12	Resistor, fixed, 3.92 k ±1% 1/4 w	Mepcoor	5213-71
R13	Resistor, variable, 500 Ω	Beckman	5290-56
R14	Resistor, fixed, 1 K ±1% 1/4 w	Mepcoor	5213-70

Table 6-6 Clamp Board A7 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, .001 µf ±10%		5302-09
C2	Capacitor, .002 µf ±10%		5302-10
C3	Capacitor, .003 µf ±10%		5302-11
C4	Capacitor, 510 pf ±5%		5300-86
C5	Capacitor, .068 µf ±10%		5302-13
C6	Same as C2		
C7	Capacitor, 200 pf ±5%		5300-74
C8	Capacitor, .001 µf	CRL	5301-15
CR1	Diode, FD100	Fairchild	5151-37
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Diode, FD300	Fairchild	5152-08
CR8	Same as CR7		
CR9	Same as CR7		
CR10	Same as CR7		
Q1	Transistor, 2N718A	Fairchild	5152-81
Q2	Same as Q1		
Q3	Same as Q1		
Q4	Transistor, 2N722	Fairchild	5152-73
Q5	Same as Q1		
Q6	Same as Q1		
Q7	Transistor, 2N2483	Fairchild	5151-97
Q8	Same as Q1		
Q9	Same as Q1		
Q10	Same as Q1		
Q11	Same as Q1		
Q12	Same as Q4		
Q13	Same as Q4		
Q14	Same as Q1		

Table 6-6 Clamp Board A7 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
Q15	Transistor, 2N720 A	Fairchild	5152-35
R1	Resistor, fixed, 47 k ±5% 1/2 w	Allen-Bradley	5215-93
R2	Resistor, fixed, 22 k ±5% 1/2 w	Allen-Bradley	5215-85
R3	Same as R2		
R4	Resistor, fixed, 68 k ±5% 1/2 w	Allen-Bradley	5215-97
R5	Same as R4		
R6	Same as R2		
R7	Same as R4		
R8	Same as R4		
R9	Same as R1		
R10	Same as R4		
R11	Same as R4		
R12	Same as R4		
R13	Same as R4		
R14	Resistor, fixed, 10 k ±5% 1/2 w	Allen-Bradley	5215-76
R15	Resistor, fixed, 100 k ±5% 1/2 w	Allen-Bradley	5216-02
R16	Resistor, fixed 510 k ±5% 1/2 w	Allen-Bradley	5216-20
R17	Resistor, fixed, 33 k ±5% 1/2 w	Allen-Bradley	5215-89
R18	Same as R4		
R19	Same as R4		
R20	Same as R4		
R21	Resistor, fixed, 16 k ±5% 1/2 w	Allen-Bradley	5215-82
R22	Same as R14		
R23	Same as R4		
R24	Same as R4		
R25	Same as R14		
R26	Resistor, fixed, 470 k ±5% 1/2 w	Allen-Bradley	5216-19
R27	Same as R4		
R28	Resistor, fixed, 1.5 M ±5% 1/2 w	Allen-Bradley	5216-32
R29	Same as R14		
R30	Same as R4		
R31	Same as R2		

Table 6-6 Clamp Board A7 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R32	Resistor, fixed, 15 k ±5%, 1/2 w	Allen-Bradley	5215-81
R33	Resistor, fixed 220 Ω ±5% 1/2 w	Allen-Bradley	5215-35
R34	Resistor, fixed 470 Ω ±5% 1/w 2	Allen-Bradley	5215-43
R35	Same as R34		
R36	Resistor, fixed 1 k ±5% 1/2 w	Allen-Bradley	5215-51
R37	Same as R1		
R38	Same as R15		
R39	Resistor, fixed 30k ±1% 1/2 w	Welwyn	5211-03
R40	Resistor, fixed, 14.7 k ±1%, 1/2 w	Dale	5209-90
R41	Same as R40		
R42	Same as R39		
R43	Same as R36		
R44	Same as R1		
R45	Same as R2		
R46	Resistor, fixed, 560 Ω ±5% 1 w	Allen-Bradley	5225-40
R47	Same as R14		
R48	Same as R4		

Table 6-7 Amplifier Board A8 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, 300 pf 300 v	Elmenco	5300-79
C2	Capacitor, fixed, 22 µf 35 v	Fansteel	5303-08
C3	Capacitor, fixed, .01 µf 200 v	Good-All	5302-08
C4	Capacitor, fixed, 10 µf, 20 v	Fansteel	5303-04
C5	Capacitor, fixed, .47 µf, 100 v	Electron	5301-82
C6	Capacitor, fixed, .068 µf 200 v	Good-All	5302-13
C7	Capacitor, fixed, .022 µf 200 v	Good-All	5302-10
C8	Same as C3		
C9	Same as C5		
C10	Same as C6		
C11	Same as C7		
C12	Same as C2		
C13	Same as C2		
C14	Capacitor, fixed, 56 µf 6 v	Fansteel	5303-63
C15	Capacitor, fixed, .22 µf, 100 v	Good-All	5303-88
C16	Same as C3		
C17	Capacitor, fixed, 50 pf 300 v	Elmenco	5300-59
C18	Capacitor, fixed, 360 pf 300 v	Elmenco	5300-81
C19	Same as C3		
CR1	Diode, FD2264	Fairchild	5214-42
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Same as CR1		
CR8	Transistor, 2N706	Fairchild	5151-21
CR9	Same as CR1		
CR10	Same as CR1		
CR11	Same as CR8		
DS1	Lamp, neon NE2U	General Electric	5830-43
DS2	Same as DS1		
Q1	Transistor, S15258	Fairchild	5152-15

Table 6-7 Amplifier Board A8 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
Q2	Transistor, 2N2484	Fairchild	5151-98
Q3	Transistor, 2N718A	Fairchild	5151-81
Q4	Same as Q3		
Q5	Transistor, 2N718	Fairchild	5152-34
Q6	Transistor, 2N2918	Fairchild	5152-74
Q7	Same as Q6		
Q8	Same as Q1		
Q9	Transistor, 2N3073	Fairchild	5152-47
Q10	Transistor, 2N720	Fairchild	5152-80
Q11	Transistor, 2N699	Fairchild	5151-40
Q12	Transistor, 2N1132	Fairchild	5151-39
Q13	Same as Q5		
Q14	Same as Q5		
R1	Resistor, fixed, 10 k ±5% 1/4 w	Allen-Bradley	5214-38
R2	Same as R1		
R3	Resistor, fixed, 300 k ±5% 1/4 w	Allen-Bradley	5214-12
R4	Resistor, fixed, 47 k ±5% 1/4 w	Allen-Bradley	5214-15
R5	Resistor, photo, 3H5	Fairchild	5152-57
R6	Same as R5		
R7	Resistor, fixed, 33 k ±5% 1/4 w	Allen-Bradley	5214-41
R8	Resistor, fixed, 1.1 M ±5% 1/4 w	Allen-Bradley	5214-33
R9	Resistor, fixed, 200 k ±5% 1/4 w	Allen-Bradley	5214-43
R10	Same as R9		
R11	Resistor, fixed, 4.7 M ±5% 1/4 w	Allen-Bradley	5214-14
R12	Same as R11		
R13	Same as R7		
R14	Resistor, fixed, 470 K ±5% 1/4 w	Allen-Bradley	5214-17
R15	Resistor, fixed, 2.7 Ω ±5% 1/4 w	Allen-Bradley	5214-18
R16	Same as R4		
R17	Resistor, fixed, 56 k ±5% 1/4 w	Allen-Bradley	5214-13

Table 6-7 Amplifier Board A8 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R18	Resistor, fixed, 330 k ±5% 1/4 w	Allen-Bradley	5214-04
R19	Same as R1		
R20	Resistor, fixed, 22k ±5% 1/4 w	Allen-Bradley	5214-20
R21	Same as R20		
R22	Resistor, fixed, 68 k ±5% 1/4 w	Allen-Bradley	5214-21
R23	Same as R20		
R24	Resistor, fixed, 8.2 k ±5% 1/4 w	Allen-Bradley	5214-11
R25	Resistor, fixed, 150 k ±5% 1/4 w	Allen-Bradley	5214-22
R26	Resistor, fixed 1 M ±5% 1/4 w	Allen-Bradley	5214-58
R27	Resistor, fixed, 100 Ω ±5% 1/4 w	Allen-Bradley	5214-08
R28	Same as R27		
R29	Same as R26		
R30	Resistor, fixed, 22 M ±5% 1/4 w	Allen-Bradley	5214-60
R31	Same as R11		
R32	Resistor, fixed, 47Ω ±5% 1/4 w	Allen-Bradley	5214-09
R33	Resistor, fixed, 2.7 Ω ±5%, 1/4 w	Allen-Bradley	5214-18
R34	Resistor, fixed, 360 k ±5% 1/4 w	Allen-Bradley	5214-63
R35	Resistor, fixed, 680 k ±5% 1/4 w	Allen-Bradley	5214-67
R36	Same as R33		
R37	Same as R11		
R38	Resistor, fixed, 6.2 k ±5% 1/4 w	Allen-Bradley	5214-37
R39	Resistor, fixed, 820 k ±5% 1/4 w	Allen-Bradley	5214-66
R40	Same as R1		
R41	Resistor, fixed, 510 Ω ±5% 1/4 w	Allen-Bradley	5214-51
R42	Resistor, fixed, 91 k ±5% 1/4 w	Allen-Bradley	5214-62
R43	Same as R20		
R44	Resistor, fixed, 3.3 k ±5% 1/4 w	Allen-Bradley	5214-54
R45	Resistor, fixed, 15 k ±5% 1/4 w	Allen-Bradley	5214-30
R46	Same as R32		
R47	Resistor, fixed, 220 Ω ±5% 1/4 w	Allen-Bradley	5214-27
R48	Same as R47		
R49	Same as R32		

Table 6-8 Decade Counter Board A10 Parts List

Circuit Reference	Description	Manufacturer	Part Number
C1	Capacitor, fixed, .68 µf, 100 v	Electron	5301-81
C2	Capacitor, fixed, 30 Pf, DM-15	Elmenco	5300-53
C3	Capacitor, fixed, .01 µf, 200 v	Good-All	5302-08
C4	Capacitor, fixed, .033 µf, 200 v	Good-All	5302-11
C5	Capacitor, fixed, .5 µf, 50 v	Electron	5302-69
C6	Same as C2		
CR1	Diode, FD100	Fairchild	5151-37
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Same as CR1		
CR8	Same as CR1		
Q1	Transistor 2N2483	Fairchild	5151-97
Q2	Transistor 2N3114	Fairchild	5152-75
Q3	Same as Q1		
Q4	Same as Q2		
Q5	Same as Q1		
Q6	Transistor 2N718/2N718A	Fairchild	5152-34/81
Q7	Same as Q1		
Q8	Same as Q6		
Q9	Same as Q6		
Q10	Same as Q1		
Q11	Same as Q6		
Q12	Same as Q6		
Q13	Same as Q1		
Q14	Not assigned		
Q15	Same as Q1		
Q16	Transistor 2N2696	Fairchild	5152-19

Table 6-8 Decade Counter Board A10 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
Q17	Same as Q6		
Q18	Transistor 2N914	Fairchild	5151-99
Q19	Same as Q1		
Q20	Same as Q2		
Q21	Same as Q1		
Q22	Same as Q1		
Q23	Same as Q2		
μL1	Micrologic element, 910	Fairchild	5152-82
μL2	Same as μL1		
μL3	Same as μL1		
μL4	Micrologic element, 923	Fairchild	5152-83
μL5	Same as μL4		
μL6	Same as μL4		
μL7	Micrologic element 914	Fairchild	5152-58
μL8	Same as μL4		
μL9	Same as μL4		
R1	Resistor, fixed, 3.6 k ±5%, 1/4 w	Allen-Bradley	5214-55
R2	Same as R1		
R3	Same as R1		
R4	Resistor, fixed, 20k ±5%, 1/4 w	Allen-Bradley	5214-40
R5	Resistor, fixed, 15k ±5%, 1 w	Allen-Bradley	5225-66
R6	Same as R5		
R7	Same as R1		
R8	Resistor, fixed, 1.5k ±5%, 1/4 w	Allen-Bradley	5214-53
R9	Same as R1		
R10	Same as R1		
R11	Same as R4		
R12	Same as R4		
R13	Not assigned		
R14	Same as R5		
R15	Same as R5		

Table 6-8 Decade Counter Board A10 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R20	Not assigned		
R21	Same as R4		
R22	Same as R8		
R23	Same as R4		
R24	Not assigned		
R25	Same as R4		
R26	Resistor, fixed, 220k, ±5%, 1/4 w	Allen-Bradley	5214-44
R27	Same as R8		
R28	Same as R4		
R29	Not assigned		
R30	Same as R4		
R31	Same as R1		
R32	Same as R4		
R33	Same as R8		
R34	Same as R1		
R35	Resistor, fixed, 110k, ±5%, 1/4 w	Allen Bradley	5214-56
R36	Resistor, fixed, 4.3k, ±5%, 1/4 w	Allen Bradley	5214-05
R37	Same as R35		
R38	Resistor, fixed, 30k, ±5%, 1/4 w	Allen Bradley	5214-01
R39	Same as R8		
R40	Resistor, fixed, 390 Ω ±5%, 1/4 w,	Allen Bradley	5214-36
R41	Same as R36		
R42	Same as R4		
R43	Not assigned		
R45	Same as R1		
R46	Same as R4		
R47	Same as R1		
R48	Same as R5		
R49	Same as R4		
R50	Same as R4		
R51	Same as R5		
R52	Same as R1		
R53	Same as R1		

Table 6-8 Decade Counter Board A10 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R54	Same as R1		
R55	Same as R17		
R56	Same as R5		
R57	Same as R5		
R58	Same as R26		
V1	Tube, electron, ZM1030	Amperex	5102-89
V2	Same as V1		
V3	Same as V1		
V4	Same as V1		
V5	Same as V1		
R44	Same as R1		
R16	Same as R4		
R17	Resistor, fixed, 3M, ±5%, 1/4 w	Allen-Bradley	5214-59
R18	Same as R8		
R19	Same as R20		

Table 6-9 Power Supply and Logic Board All Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, .001 µf, disc	Cornell-Dublier	5301-15
C2	Capacitor, fixed, 1 µf, 50 v	Cornell-Dublier	5300-21
C3	Capacitor, fixed, 250 µf, 50 v	Cornell-Dublier	5300-07
C4	Capacitor, fixed, 0.1 µf, 75 v, disc	CRL	5303-91
C5	Same as C3		
C6	Capacitor, fixed, 680 pf	Elmenco	5300-89
C7	Capacitor, fixed, .05 µf, 50 v disc	Sprague	5301-24
C8	Same as C7		
C9	Capacitor, fixed, 500 µf, 6 v	Cornell-Dublier	5303-97
C10	Capacitor, fixed, .47 µf, 100 v	Electron	5303-82
C11	Capacitor, fixed, 12 µf, 350 v	Cornell-Dublier	5303-96
C12	Capacitor, fixed, 2000 µf, 12 v	Cornell-Dublier	5303-98
CR1	Diode, 1N4003	Fairchild	5152-71
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Diode, FD100	Fairchild	5152-37
CR6	Same as CR5		
CR7	Same as CR5		
CR8	Same as CR5		
CR9	Same as CR5		
CR10	Same as CR5		
CR11	Same as CR5		
CR12	Same as CR5		
CR13	Same as CR5		
CR14	Same as CR5		
CR15	Same as CR5		
CR16	Same as CR5		
CR17	Same as CR5		
CR18	Same as CR5		
CR19	Same as CR5		
CR20	Same as CR5		

Table 6-9 Power Supply and Logic Board All Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
CR21	Same as CR5		
CR22	Same as CR5		
CR23	Same as CR5		
CR24	Same as CR5		
CR25	Same as CR5		
CR26	Same as CR5		
CR27	Same as CR5		
CR28	Same as CR5		
CR29	Same as CR5		
CR30	Same as CR5		
CR31	Same as CR5		
CR32	Same as CR5		
CR33	Same as CR5		
CR34	Same as CR5		
CR35	Same as CR5		
CR36	Same as CR5		
CR37	Same as CR5		
CR38	Same as CR5		
CR39	Same as CR5		
CR40	Same as CR5		
CR41	Diode, zener, selected	Fairchild	A606982
CR42	Diode, 1N2071	Fairchild	5150-15
CR43	Same as CR42		
CR44	Same as CR42		
CR45	Same as CR42		
CR46	Same as CR1		
CR47	Same as CR1		
Q1	Transistor, 2N3114	Fairchild	5152-75
Q2	Transistor, 2N718	Fairchild	5152-34
Q3	Same as Q2		
Q4	Same as Q1		
Q5	Same as Q2		

Table 6-9 Power Supply and Logic Board All Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
Q6	Transistor, 2N706	Fairchild	5152-21
Q7	Same as Q2		
Q8	Same as Q6		
Q9	Same as Q2		
Q10	Transistor, 2N722	Fairchild	5152-73
Q11	Same as Q10		
Q12	Same as Q10		
Q13	Same as Q10		
Q14	Same as Q10		
Q15	Same as Q10		
Q16	Same as Q10		
Q17	Same as Q10		
Q18	Same as Q10		
Q19	Same as Q1		
Q20	Same as Q1		
Q21	Same as Q1		
Q22	Same as Q1		
Q23	Same as Q1		
Q24	Same as Q1		
Q25	Same as Q1		
Q26	Same as Q1		
Q27	Transistor, 2N2484	Fairchild	5151-98
Q28	Transistor, TP6206LA	Fairchild	5152-12
Q29	Same as Q10		
Q30	Same as Q27		
R1	Resistor, fixed, 1 k, ±5%, 1/2 w	Allen-Bradley	5215-51
R2	Resistor, fixed, 22 k, ±5%, 1/2 w	Allen-Bradley	5215-85
R3	Same as R2		
R4	Resistor, fixed, 220 Ω, ±5%, 1/2 w	Allen-Bradley	5215-35
R5	Resistor, fixed, 470 k, ±5%, 1/2 w	Allen-Bradley	5216-19
R6	Same as R2		
R7	Same as R1		

Table 6-9 Power Supply and Logic Board All Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R8	Resistor, fixed, 56 k, ±5%, 1/2 w	Allen-Bradley	5215-95
R9	Resistor, fixed, 4.7 k ±5% 1/2 w	Allen-Bradley	5215-68
R10	Same as R2		
R11	Resistor, fixed, 220 k, ±5%, 1/2 w	Allen-Bradley	5216-11
R12	Resistor, fixed, 47 k, ±5%, 1/2 w	Allen-Bradley	5215-93
R13	Resistor, fixed, 10 k, ±5%, 1/2 w	Allen-Bradley	5215-76
R14	Resistor, fixed, 68 k, ±5%, 1/2 w	Allen-Bradley	5215-97
R15	Resistor, fixed, 33 k, ±5%, 1/2 w	Allen-Bradley	5215-89
R16	Same as R9		
R17	Resistor, fixed, 560 Ω, ±5%, 1/2 w	Allen-Bradley	5215-45
R18	Same as R12		
R19	Same as R14		
R20	Same as R15		
R21	Same as R15		
R22	Same as R9		
R23	Same as R1		
R24	Same as R1		
R25	Resistor, fixed, 200 k, ±5%, 1/2 w	Allen-Bradley	5216-10
R26	Same as R25		
R27	Same as R25		
R28	Same as R25		
R29	Same as R25		
R30	Same as R25		
R31	Same as R25		
R32	Same as R25		
R33	Same as R25		
R34	Same as R25		
R35	Same as R25		
R36	Same as R25		
R37	Same as R25		
R38	Same as R25		
R39	Same as R25		
R40	Same as R25		

Table 6-9 Power Supply and Logic Board All Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R41	Same as R25		
R42	Same as R25		
R43	Same as R25		
R44	Same as R25		
R45	Same as R25		
R46	Same as R25		
R47	Same as R25		
R48	Same as R25		
R49	Same as R25		
R50	Same as R25		
R51	Same as R25		
R52	Resistor, fixed, 430Ω, ±5%, 1/2 w	Allen-Bradley	5215-42
R53	Same as R52		
R54	Same as R52		
R55	Same as R52		
R56	Same as R52		
R57	Same as R12		
R58	Same as R12		
R59	Same as R12		
R60	Same as R4		
R61	Resistor, fixed, 2.4 k, ±5%, 1/2 w	Allen-Bradley	5215-61
R62	Resistor, fixed, 5.6 k, ±5%, 1/2 w	Allen-Bradley	5215-70
R63	Resistor, variable 10 k,	Beckman	5290-60
R64	Resistor, fixed, 120 k, ±5%, 1/2 w	Allen-Bradley	6215-04
R65	Resistor, fixed, 11 Ω, ±5%, 1 w	Allen-Bradley	5220-02

Table 6-10 Power Transformer Sub-Chassis A12 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
S2	Switch DPDT		5604-65
T1	Transformer, Power	Topaz	5401-17

Table 6-11 Rear Panel Assembly A13 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
F1	Fuse, 1 amp, (0.5 amp for 230 v operation)		
	Fan, whisper F1C2	Rotron	6202-54
	Filter, fan		608273
	Screen, fan		608272C

Table 6-12 Front Panel Assembly A14 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
DS1	Lamp, neon	Diallo	5810-29
DS2	Same as DS1		
DS3	Same as DS1		
DS4	Same as DS1		
DS5	Same as DS1		
DS6	Same as DS1		
DS7	Same as DS1		
DS8	Same as DS1		
DS9	Same as DS1		
DS10	Same as DS1		
DS11	Same as DS1		
DS12	Lamp, 28 v #327	Dialco	5800-97
DS13	Same as DS12		
R1	Resistor, variable 2.5 MΩ CU2552	Ohmite	5290-05
S1	Switch, push, red	Marco-Dak	5604-89

Table 6-13 DM-01A Plug-In Assembly A15 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
P1	Connector, 26 pin	Amphenol	6124-33
S1	Switch, Rotary	Oak	5605-13

Table 6-14 Range Assembly A16 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
CR1	Diode, FD100	Fairchild	5152-37
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Same as CR1		
CR8	Same as CR1		
CR9	Same as CR1		
CR10	Same as CR1		
CR11	Same as CR1		
CR12	Same as CR1		
CR13	Same as CR1		
CR14	Same as CR1		
CR15	Same as CR1		
CR16	Same as CR1		
CR17	Same as CR1		
K1	Relay, Reed, MR832	Gordos	
K2	Same as K1		
K11	Reed, Relay, MR936	Gordos	
LK1A	Coil, relay, S32	Coto	5601-45
LK1B	Same as LK1A		
LK2A	Same as LK1A		
LK2B	Same as LK1A		
LK3	Coil, relay U32	Coto	5602-91
LK4	Same as LK3		
LK5	Same as LK3		
LK6	Same as LK3		
LK7	Same as LK3		
LK8	Same as LK3		
LK9	Same as LK3		
LK10	Same as LK3		

Table 6-14 Range Assembly A16 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
LK12	Same as LK3		
LK13	Same as LK3		
LK14	Same as LK3		
LK15	Same as LK3		
LK16	Same as LK3		
LK17	Same as LK3		
LK11A	Coil, relay, U24-P	Coto	
LK11B	Same as LK11A		

Table 6-15 Range Board A17 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
K1	Not assigned		
K2	Not assigned		
K3	Relay, reed, BRM-901	RBM Controls	5604-90
K4	Same as K3		
K5	Same as K3		
K6	Same as K3		
K7	Same as K3		
K8	Same as K3		
K9	Same as K3		
K10	Same as K3		
K11	Not assigned		
K12	Same as K3		
K13	Same as K3		
K14	Same as K3		
K15	Same as K3		
K16	Same as K3		
K17	Same as K3		
R1	Resistor, variable, 1K	Beckman	5291-67
R2	Resistor, variable, 500 Ω	Beckman	5291-54
R3	Resistor, fixed, 1 M	Cal. Std. Corp.	5219-99
R4	Resistor, fixed, 100K	Cal. Std. Corp.	5219-99
R5	Resistor, fixed, 10K	Cal. Std. Corp.	5219-99
R6	Same as R4		
R7	Same as R3		
R8	Resistor, fixed, 10M	Cal. Std. Corp.	5219-99
R9	Resistor, variable, 100Ω	Beckman	5291-66
R10	Same as R2		
R11	Same as R1		
R12	Resistor, variable, 10K	Beckman	5291-68
	Note: R3 through R8 are a matched set.		

Table 6-16 Decimal Point Encoder Board A18 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
CR1	Diode, FD200	Fairchild	5151-90
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Same as CR1		
CR8	Same as CR1		
CR9	Same as CR1		
Q1	Transistor, 2N2483	Fairchild	5152-20
Q2	Same as Q1		
Q3	Same as Q1		
R1	Resistor, fixed, 130 k ±5% 1/2 w	Allen-Bradley	5216-05
R2	Resistor, fixed, 16 k ±5% 1/2 w	Allen-Bradley	5215-82
R3	Resistor, fixed, 3.9 k ±5% 1/2 w	Allen-Bradley	5215-66
R4	Resistor, fixed, 20 k ±5% 1/2 w	Allen-Bradley	5215-84
R5	Same as R1		
R6	Same as R2		
R7	Same as R3		
R8	Same as R4		
R9	Same as R1		
R10	Same as R2		
R11	Same as R3		
R12	Same as R4		

Table 6-17 Recommended Spare Parts and Circuit Board List

Description	F.I. Part No.	Total Used	Recommended Spares	Unit Price
	PARTS			
Coil, relay, S32	5601-45	4	2	$ 2.00
Coil, relay, U32	5602-91	15	2	2.80
Diode, FD200	5151-90	8	2	6.50
Diode, FD300	5152-08	13	2	4.50
Diode, FD2264	5152-42	79	2	6.00
Diode, IN6071	5150-15	4	2	2.00
Diode, IN4003	5152-71	6	2	8.00
Fuse, 3A, 1 amp	5705-56	1	10	.20
Fuse, 0.5 amp				
Lamp, neon	5810-29	11	2	1.49
Lamp, 28V, #327	5800-97	2	10	.75
Lamp, neon, NE-ZU	5830-43	2	2	.35
Micrologic Element μL910	5152-82	12	2	4.00
Micrologic Element μL914	5152-58	4	2	20.00
Micrologic Element μL923	5152-83	20	2	4.59
Relay, Reed, MR830	5604-87	3	5	2.50
Relay, Reed, BRM901	5604-90	14	2	1.80
Transistor, 2N2483	5151-97	3	2	7.50
Transistor, TP6206LA	5152-12	1	2	30.00
Transistor, 2N699 (Selected)	5154-02	1	2	12.00
Transistor, 2N699	5152-80	1	2	2.64
Transistor, 2N706	5152-21	2	2	1.80
Transistor, 2N708	5151-36	10	2	2.20
Transistor, 2N718	5152-34	34	2	2.50

Table 6-17 Recommended Spare Parts and Circuit Board List (Cont)

Description	F.I. Part No.	Total Used	Recommended Spares	Unit Price
Transistor, 2N720	5152-35	16	2	$ 4.00
Transistor, 2N722	5152-13	18	2	7.00
Transistor, 2N871	5152-28	1	2	15.00
Transistor, 2N914	5151-97	1	2	2.00
Transistor, 2N956	5152-27	1	2	2.75
Transistor, 2N1132	5151-39	2	2	7.00
Transistor, 2N1893	5151-92	3	2	3.50
Transistor, 2N2297	5151-27	2	2	17.00
Transistor, 2N2368	5154-04	2	2	5.00
Transistor, 2N2483	5151-20	28	2	8.10
Transistor, 2N2484	5151-98	7	2	10.00
Transistor, 2N2696	5152-19	1	2	8.00
Transistor, 2N2918	5152-74	2	2	33.00
Transistor, 2N2920	5154-06	8	2	54.00
Transistor, 2N3073	5154-16	2	2	12.00
Transistor, 2N3114	5152-75	20	2	12.00
Tube, Electron ZM1030	5103-89	5	2	15.00
Voltage Reference, RVL-1	6905-22	1	1	125.00
CIRCUIT BOARDS				
Board, plug-in, A1	6632-05	1	1	66.00
Board, plug-in, A2	6632-04	1	1	97.00
Board, plug-in, A3	6632-03	1	1	96.00
Board, plug-in, A4	6632-06	1	1	49.00
Board, plug-in, A5, A6	6905-20	2	1	87.00
Board, plug-in A7	6632-07	1	1	32.00
Board, plug-in, A8	6632-09	1	1	96.00
Board, plug-in, A10	6632-02	1	1	242.00
Board, plug-in, A11	6632-01	1	1	105.00

APPENDIX E

Detailed information on Automatic Ranging option available for use with Model 7100 Integrating Digital Meter.

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E-1. PURPOSE

E-2. This appendix describes in detail the automatic ranging option available for use with the Model 7100 Integrating Digital Meter.

E-3. DESCRIPTION

E-4. The ranging option consists of a printed circuit plug-in board, designated A19, designed to fit into connector XA19 wired into all models of the 7100, serial number 135 and beyond. (This permits the option to be easily installed on manual range versions of these instruments.) Automatic ranging operates on volts and ohms readout. In both cases, when the Function/Range switch is set to the appropriate "Auto" position, the meter performs a ranging cycle prior to the start of every measurement cycle. This cycle consists of automatically selecting each range in turn, starting with the lowest, and monitoring the state of the clamp across the input ranging amplifier. If the amplifier is clamped (input signal greater than range limit) the ranging logic progressively selects higher ranges until a range is reached where the amplifier is unclamped (input signal lower than range limit). At this point, the ranging logic locks the instrument in that range and generates a measurement cycle "start" signal that initiates a normal measurement cycle. If the amplifier is still clamped when the highest range is reached, the meter remains in the ranging mode and no measurement start signal is generated. The duration of the ranging steps is approximately 60 milliseconds therefore the maximum ranging period is 300 milliseconds for volts (5 ranges) and 240 milliseconds for ohms (4 ranges). A more detailed description of the ranging circuitry follows below:

E-5. CIRCUIT DESCRIPTION

E-6. Figure E-1 is a block diagram of board A19 and associated circuitry in the meter. Board A19 consists basically of a) a ring counter, triggered by range transfer pulses from clamp board A7, with five output lines,only one of which is in a particular state at any given time b) switching logic, selected by the "auto" positions of the Function/Range switch and controlled by the ring counter output, that provides a ground return for

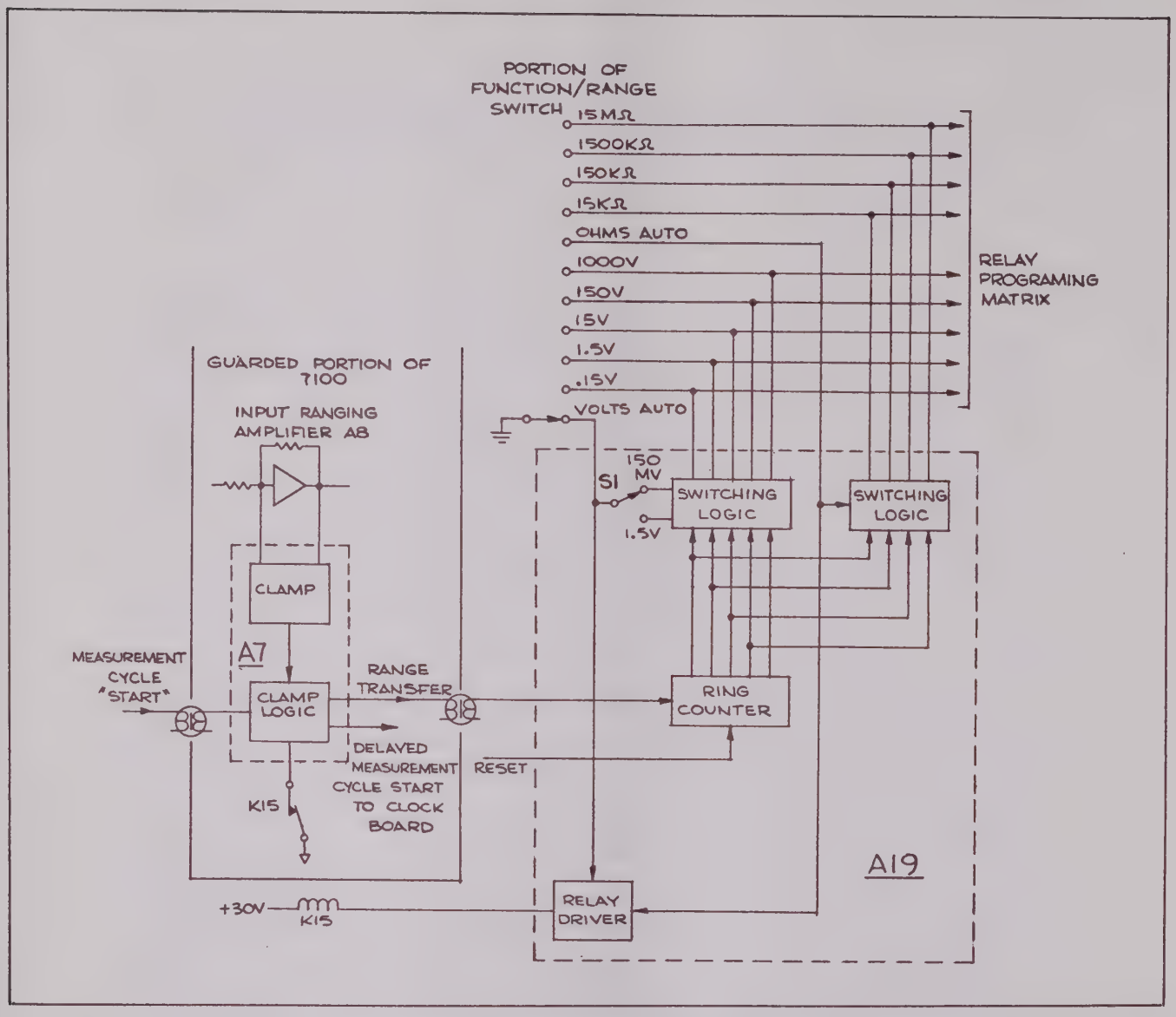

Figure E-1 Auto Ranging Block Diagram

each of the volts and ohms relay programing matrix lines and c) a relay driver, also activated by the "auto" switch position, that pulls in relay K15 on range board A17. The remainder of the automatic ranging logic is mounted on the standard clamp board A7 fitted in all versions of the instrument. In general, ranging takes place as follows: when "auto volts" or "auto ohms" is selected, relay K15 is energised to a) disable the front panel overload indicator and b) set up the clamp logic for auto ranging. The meter reset pulse a) resets the readout counter to zero (10000) and b) resets the ring counter so that its output causes the programing relays

for the lowest range (volts or ohms, according to Function/Range switch setting) to be pulled in. Approximately 20 msec later, the measurement cycle start pulse sets up the clamp logic to check the state of the clamp across ranging amplifier A8. If the amplifier is clamped, the logic produces a range transfer pulse that moves the ring counter forward one step. This pulls in the next higher range. The circuit continues to produce range transfer pulses at approximately 60 msec intervals until the correct range is reached. The resulting change in the clamp condition then a) stops production of further transfer pulses, so that the ring counter remains in its last position and b) initiates a delayed measurement cycle start pulse that starts the readout cycle. The decimal readout lamps are energised during the ranging cycle therefore an initial readout of 10000 will be observed before the actual readout. In the event that the input signal is greater than the limit on the last range (1000 volts or 15 MΩ), the readout remains at 10000. A switch on A19 is provided to cut in or out the first ranging position on the "volts" mode logic so that the ranging process can start from the lowest range (150 mv) or the next lowest (1.5 v).

E-7. CLAMP LOGIC

E-8. Figure E-2 is a basic diagram of the automatic ranging logic mounted on clamp board A7. Circuit action is controlled by relay K15 located on range board A16. In all positions of the Function/Range switch except "auto", relay K15 is open with the result that Q2 is held saturated by a +30 volt bias and Q1 is off. Then, each time the measurement start pulse is applied to the base of Q1, it acts as a simple inverter and passes the pulse, without delay, to the clock board to start a measurement cycle. When "auto" is selected, K15 is closed and removes the bias from Q2 changing Q1/Q2 to a bistable multivibrator. Now, when a start pulse is applied to Q1, the flip-flop is set so that Q1 is saturated and Q2 is cut off. (No delayed start pulse is generated at this time.) The collector of Q2 is now high (+30 v) and this potential, applied at various points in the circuit, sets up the automatic ranging function. Astable multivibrator Q7/Q8 is enabled and produces an output (see figure E-3 (c)) from which are derived range transfer pulses for as long as the clamp output viewed at the junction of C7 and R45 remains high. (A delay incorporated in the logic

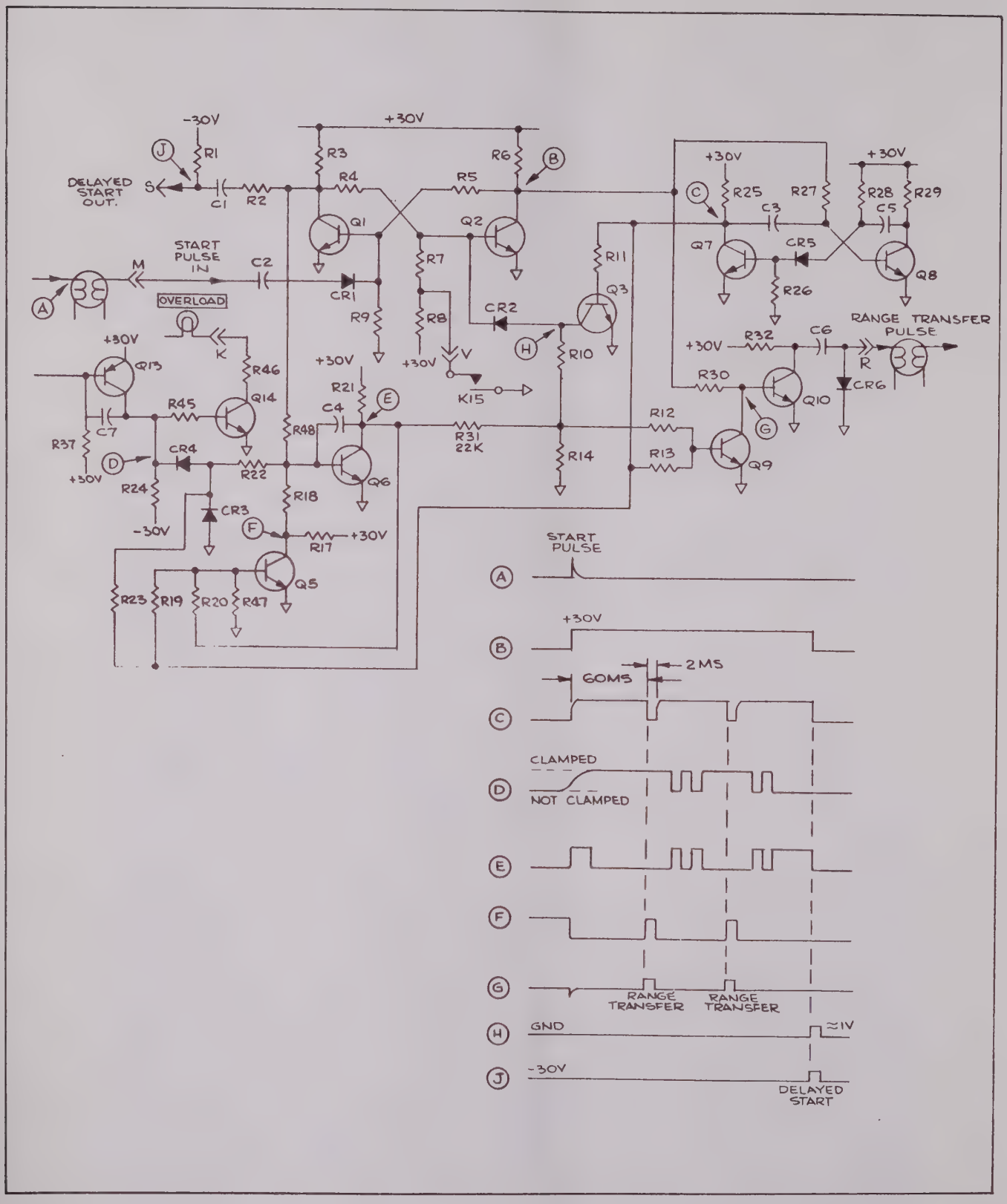

Figure E-2 Clamp Board A7 Auto Ranging Logic

prevents the momentary low going clamp signals that appear when the ranging relays are switched from one range to another from developing spurious end of ranging signals). When the clamp output falls to a constant low level, Q2 produces a signal, coincident with the next Q7/Q8 switchover that sets Q1/Q2 in its alternate state. This a) removes the +30 volt potential from the logic, preventing the generation of further range transfer pulses and b) initiates production of a delayed measurement start signal. The circuit now remains in this state until the next start pulse triggers Q1/Q2 and initiates another ranging cycle.

E-9. BOARD A19

E-10. Figure E-3 is a basic diagram of the ring counter and switching logic mounted on plug-in board A19. (See figure E-5 for full schematic). The ring counter consists of Q3 through Q7 and associated components. In operation, only one of the transistors is in a specified state at any given time and each range transfer pulse advances this specified state one position at a time in an ordered sequence. In the reset condition, all transistors are saturated with the exception of Q3 which is turned off and the application of range transfer pulses turn Q4, Q5, etc. off in turn. The counter operates as follows: The system reset signal is stretched by Q1, Q2 and the negative pulse appearing at the collector of Q2 turns Q3 off. The collector of Q3 goes high (approximately 19.3 v) and this provides base drive to turn on Q4 through Q7. The bias on the anode of diode CR3 is approximately 20 volts and zero on the anodes of CR4 through CR7. Thus, when the negative going range transfer pulse occurs, only diode CR3 conducts and this discharges capacitor C4 (charged to the collector voltage of Q3) and provides a turn off current for Q4. The collector of Q4 now goes high and a) turns on Q3 and b) charges capacitor C5. The circuit continues to operate in a similar fashion, the diodes steering the range transfer pulses to turn off each transistor in turn, simultaneously turning on the preceding one. When the range transfer pulses cease, the counter remains in the state determined by the last range transfer until the reset pulse returns it to its reset condition.

E-11. The switching logic is activated by the ring counter and simulates the ground return applied to the relay programing matrix lines by the

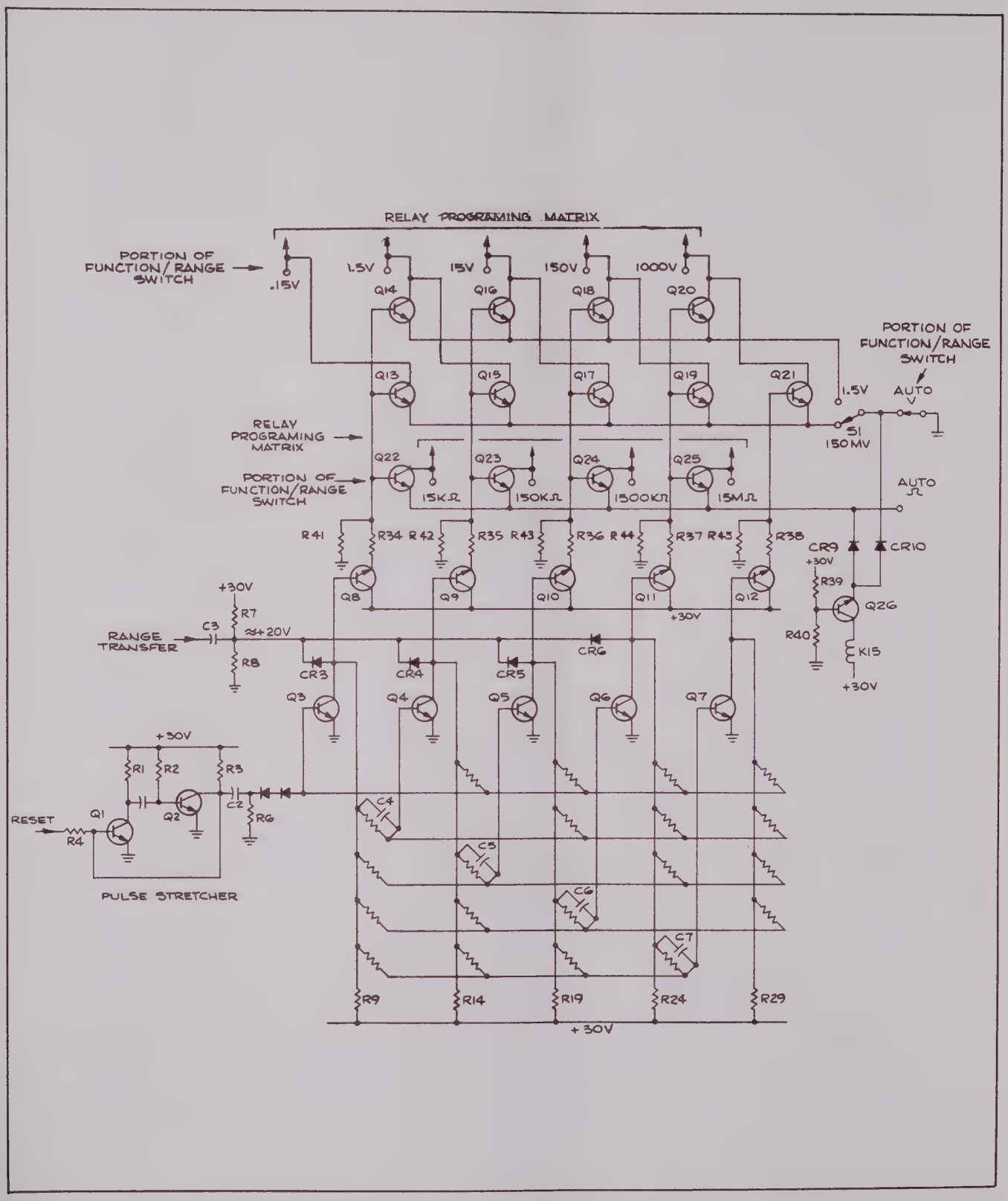

Figure E-3 Board A19 Basic Schematic

manual positions of the Function/Range switch. In order to describe circuit operation, assume that a) the ring counter is in the reset state (Q3 off, Q4 through Q7 on), b) the Function/Range switch is set to "volts auto", and c) switch S1 on board A19 is set to "150 mv". These are the conditions shown in figure E-3. Transistors Q8 through Q12 are connected as emitter followers. The +20 volt potential at the collector of Q3 appears, less a drop of approximately 0.5 volts, at the emitter of Q8 and a divider, consisting of R34 and R41 applies approximately 4.5 volts to the base of Q13, Q14 and Q22. However, only the emitter of Q13 is grounded (via the contacts of switch S1 and the "volts auto" position of the Function/Range switch) therefore Q13 is turned on and provides a ground return for the .15 volt range relay programing matrix line. Then, as the ring counter advances through its programed conditions Q15, Q17, Q19, and Q21 similarly provide ground paths for the remaining volt range lines. When switch S1 is set to the 1.5 volt position, Q14 through Q20 are connected into circuit, omitting the .15 volt line from the ranging process. Transistors Q22 through Q25 provide control for ohms automatic ranging.

E-12. Transistor Q26 is the relay driver for relay K15. The relay is activated when the Function/Range switch is set to either "volts auto" or "ohms auto".

E-13. MODEL NUMBER

E-14. In addition to the Model 7100 designation appearing on the front panel of all versions of the instrument, another number identifying the readout capabilities of a particular instrument appears on the serial number tab at the rear of the meter. For models delivered with auto ranging, these numbers are:

Readout	Model Number
Volt-Ohm-Ratio	7101
Volt-Ohm	7111
Volt-Ratio	7121
Volt	7141

E-15. COMPONENT LOCATION AND REPLACEMENT

E-16. Figure E-4 is a photograph showing the location of the components mounted on automatic ranging plug-in board A19 and table E-1 contains information for ordering replacement parts for the board.

E-17. WIRING DIAGRAM

E-18. Figures E-6 through E-9 are wiring diagrams for Models 7101 through 7141 described above.

E-19. INPUT VOLTAGE LIMITATION

E-20. The maximum input voltage that can be applied to the lowest voltage range (150 mv) during autoranging is ±500 volts. Any voltage in excess of this value may damage the instrument.

-21. SWITCH S1

E-22. Switch S1 on plug-in card A19 provides a means of protecting the instrument from the overload condition described in paragraph E-20. When the switch is set to the 150 mv position, autoranging takes place on all ranges beginning with the lowest; when the 1.5 v position is selected, the lowest range is disabled and ranging begins with the 1.5 v range. All instruments are delivered with S1 set to the 1.5 v position.

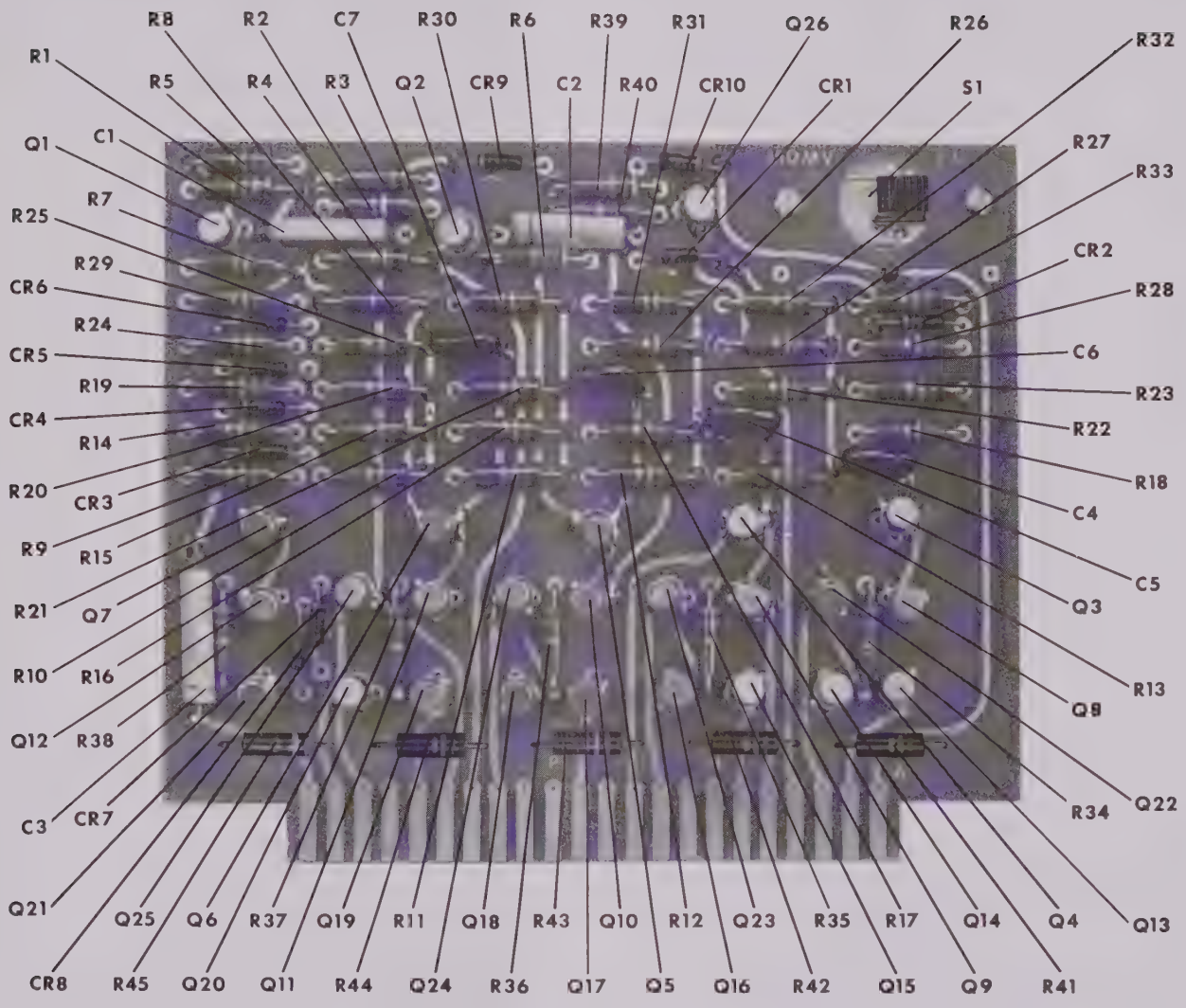

Figure E-4 Auto Range Board A19 Parts Identification

Table E-1 Auto Range Board A19 Parts List

Circuit Reference	Description	Manufacturer	FSC Part Number
C1	Capacitor, .01 μf 10%		5302-08
C2	Same as C1		
C3	Capacitor, .047 μf 10%		5302-12
C4	Capacitor, 560 pf 5%	Elmenco	5300-87
C5	Same as C4		
C6	Same as C4		
C7	Same as C4		
CR1	Diode, FD100	Fairchild	5151-37
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Same as CR1		
CR8	Same as CR1		
CR9	Same as CR1		
CR10	Same as CR1		
Q1	Transistor, 2N718A	Fairchild	5152-81
Q2	Same as Q1		
Q3	Same as Q1		
Q4	Same as Q1		
Q5	Same as Q1		
Q6	Same as Q1		
Q7	Same as Q1		
Q8	Same as Q1		
Q9	Same as Q1		
Q10	Same as Q1		
Q11	Same as Q1		
Q12	Same as Q1		
Q13	Same as Q1		
Q14	Same as Q1		

Table E-1 Auto Range Board A19 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FSC Part Number
Q15	Same as Q1		
Q16	Same as Q1		
Q17	Same as Q1		
Q18	Same as Q1		
Q19	Same as Q1		
Q20	Same as Q1		
Q21	Same as Q1		
Q22	Same as Q1		
Q23	Same as Q1		
Q24	Same as Q1		
Q25	Same as Q1		
Q26	Same as Q1		
R1	Resistor, fixed, 33 k ±5% 1/2 w	Allen-Bradley	5215-89
R2	Resistor, fixed, 120 k ±5% 1/2 w	Allen-Bradley	5216-04
R3	Same as R1		
R4	Resistor, fixed, 10 k ±5% 1/2 w	Allen-Bradley	5215-76
R5	Resistor, fixed, 68 k ±5% 1/2 w	Allen-Bradley	5215-97
R6	Resistor, fixed, 47 k ±5% 1/2 w	Allen-Bradley	5215-93
R7	Resistor, fixed, 12 k ±5% 1/2 w	Allen-Bradley	5215-78
R8	Resistor, fixed, 18 k ±5% 1/2 w	Allen-Bradley	5215-83
R9	Same as R8		
R10	Resistor, fixed, 130 k ±5% 1/2 w	Allen-Bradley	5216-05
R11	Same as R10		
R12	Same as R10		
R13	Same as R10		
R14	Same as R8		
R15	Same as R10		
R16	Same as R10		
R17	Same as R10		
R18	Same as R10		
R19	Same as R8		
R20	Same as R10		

Table E-1 Auto Range Board A19 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FSC Part Number
R21	Same as R10		
R22	Same as R10		
R23	Same as R10		
R24	Same as R8		
R25	Same as R10		
R27	Same as R10		
R28	Same as R10		
R29	Same as R8		
R30	Same as R10		
R31	Same as R10		
R32	Same as R10		
R33	Same as R10		
R34	Resistor, fixed, 3.6 k ±5% 1/2 w	Allen-Bradley	5215-65
R35	Same as R34		
R36	Same as R34		
R37	Same as R34		
R38	Same as R34		
R39	Same as R6		
R40	Resistor, fixed, 6.2 k ±5% 1/2 w	Allen-Bradley	5215-71
R41	Resistor, fixed, 1.5 k ±5%, 1/2 w	Allen-Bradley	5215-56
R42	Same as R41		
R43	Same as R41		
R44	Same as R41		
R45	Same as R41		

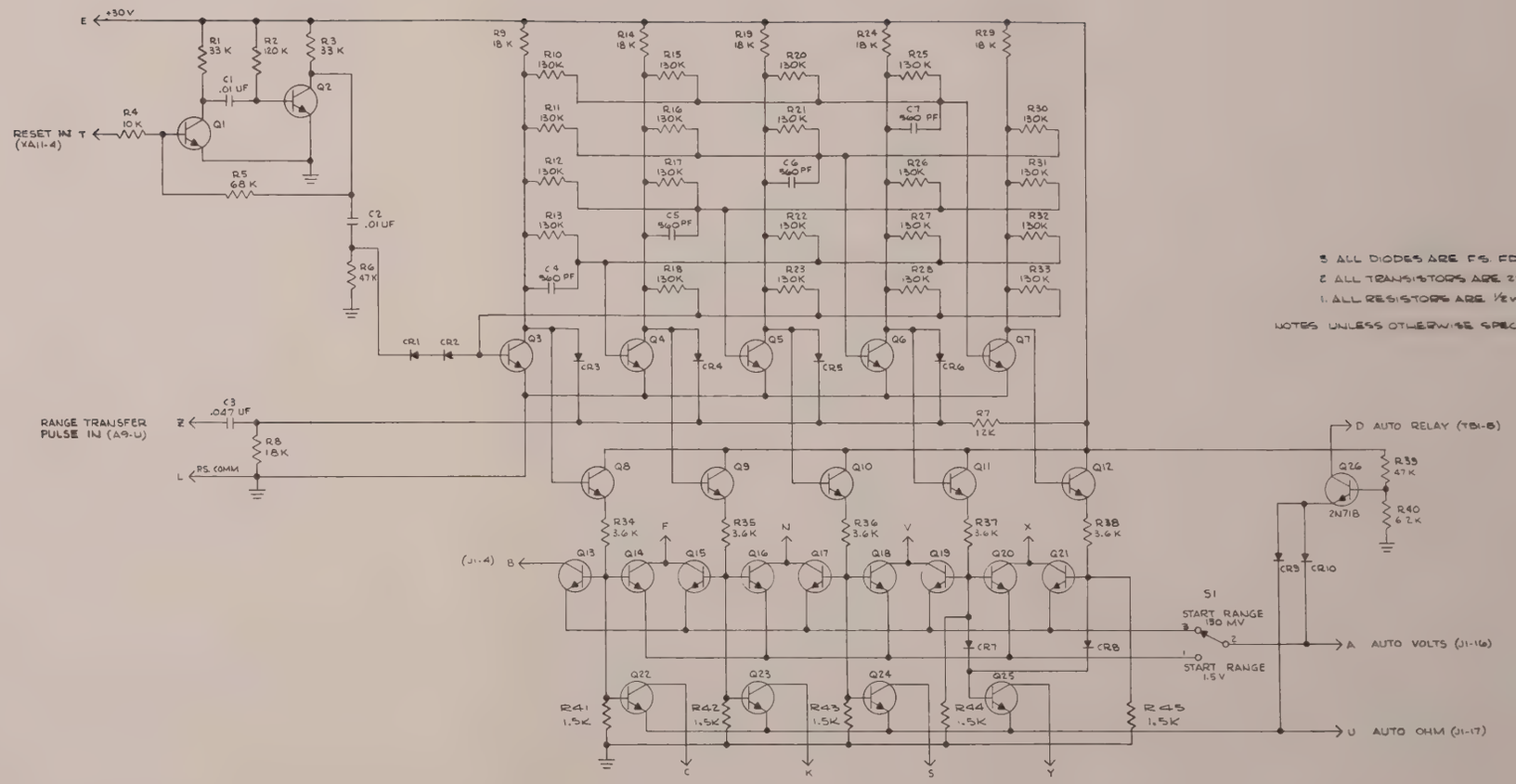

Figure E-5 Auto Range Board A19
Schematic

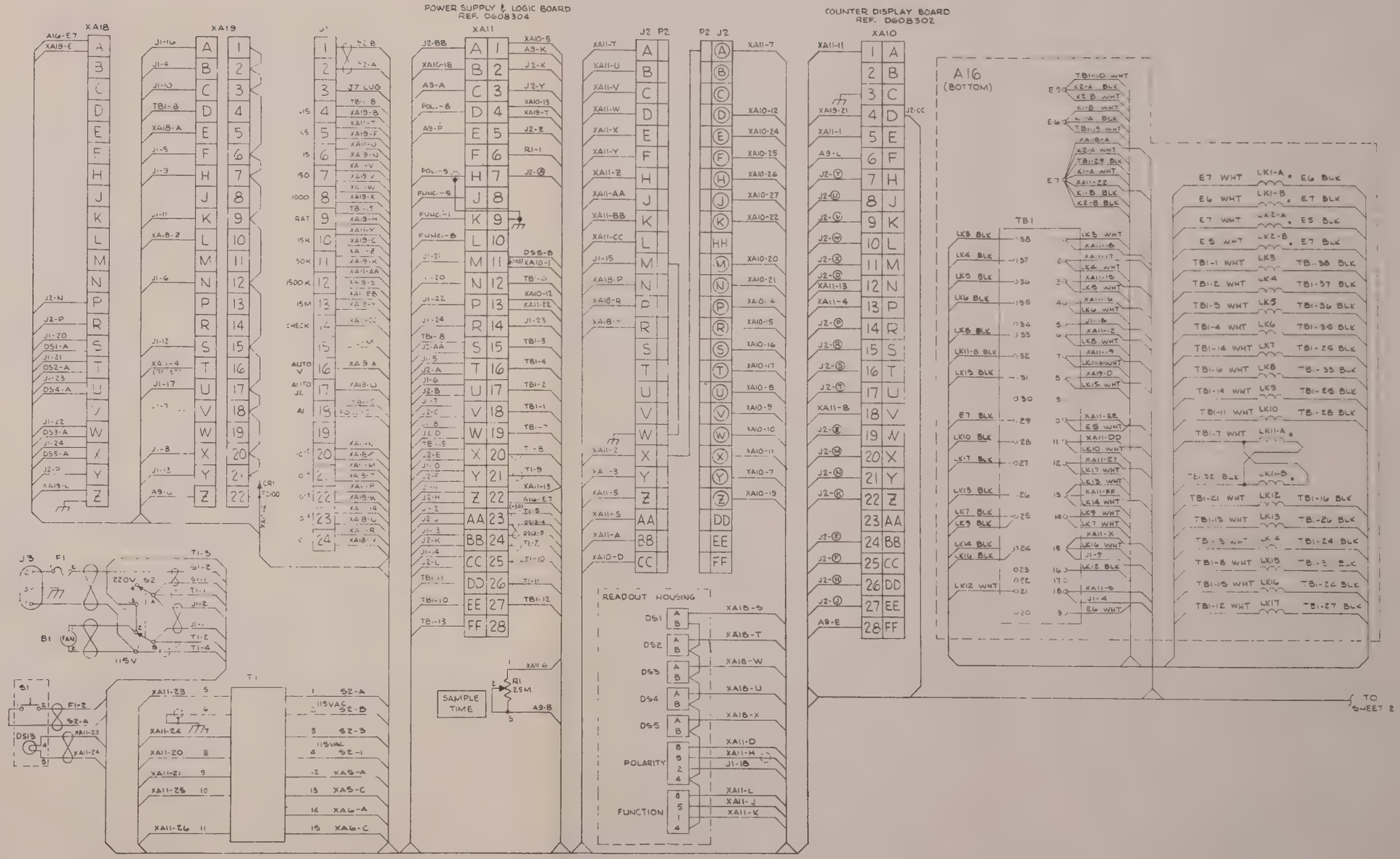

Figure E-6 Model 7101 Wiring Diagram
(Sheet 1 of 2)

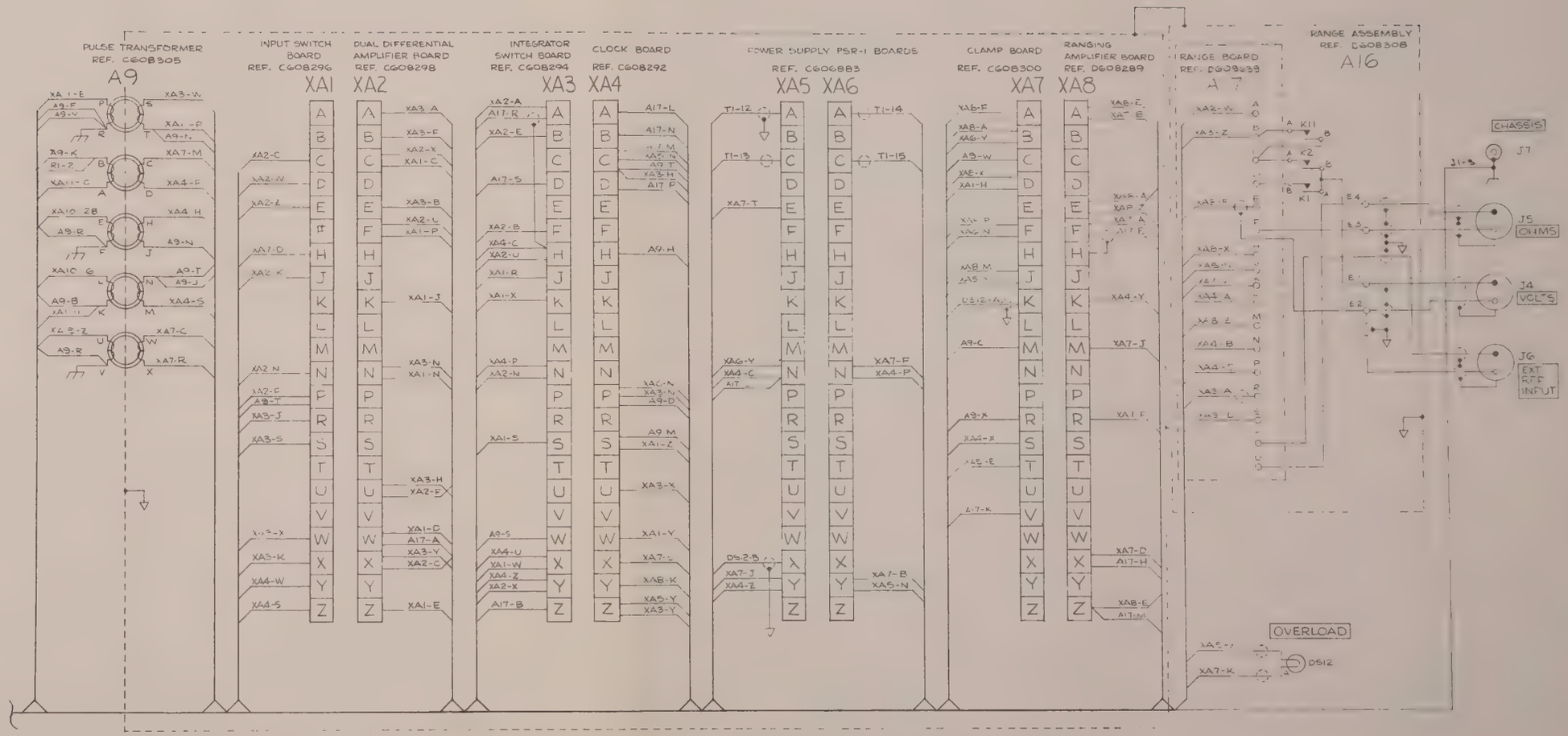

Figure E-6 Model 7101 Wiring Diagram
(Sheet 2 of 2)

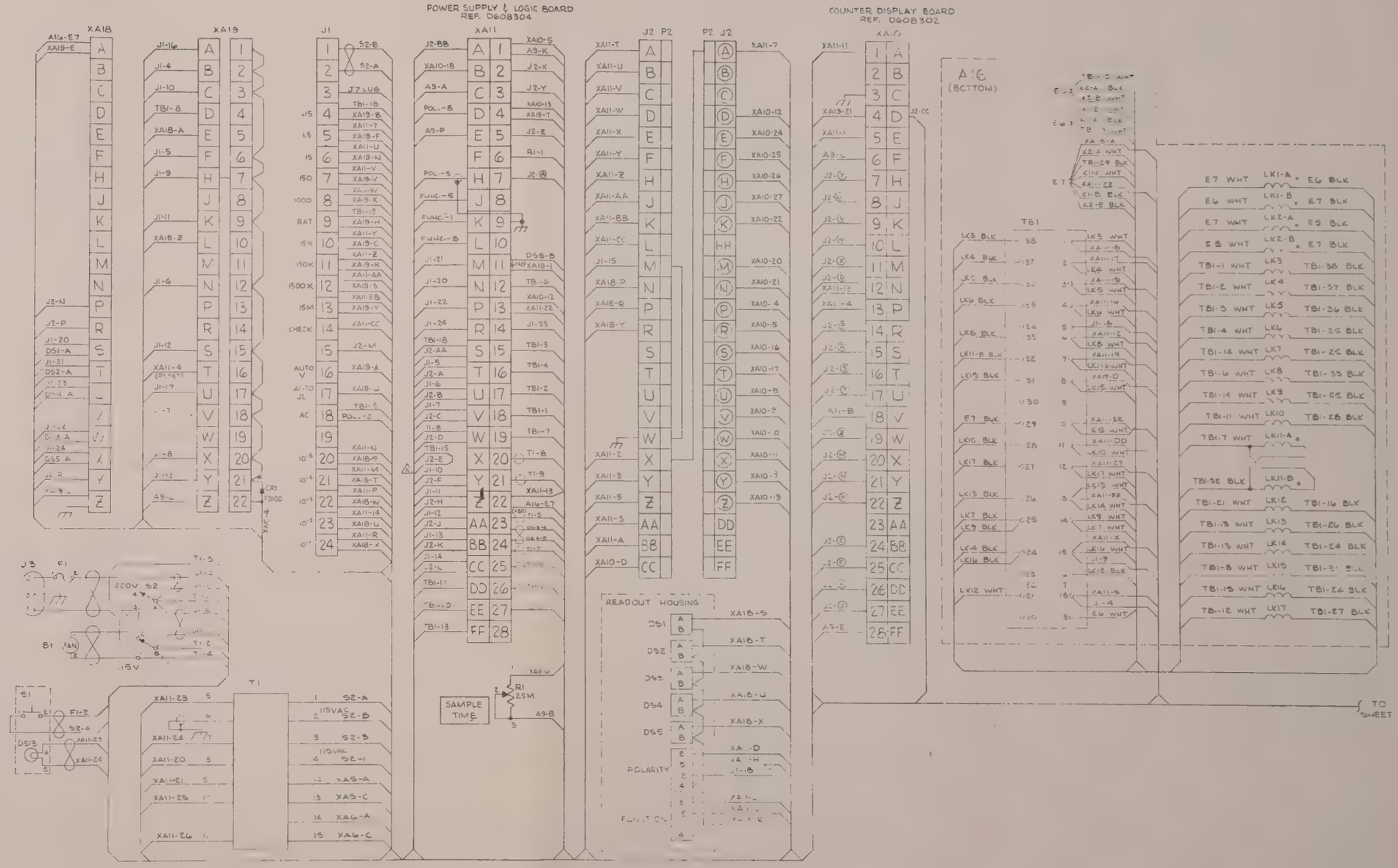

Figure E-7 Model 7111 Wiring Diagram
(Sheet 1 of 2)

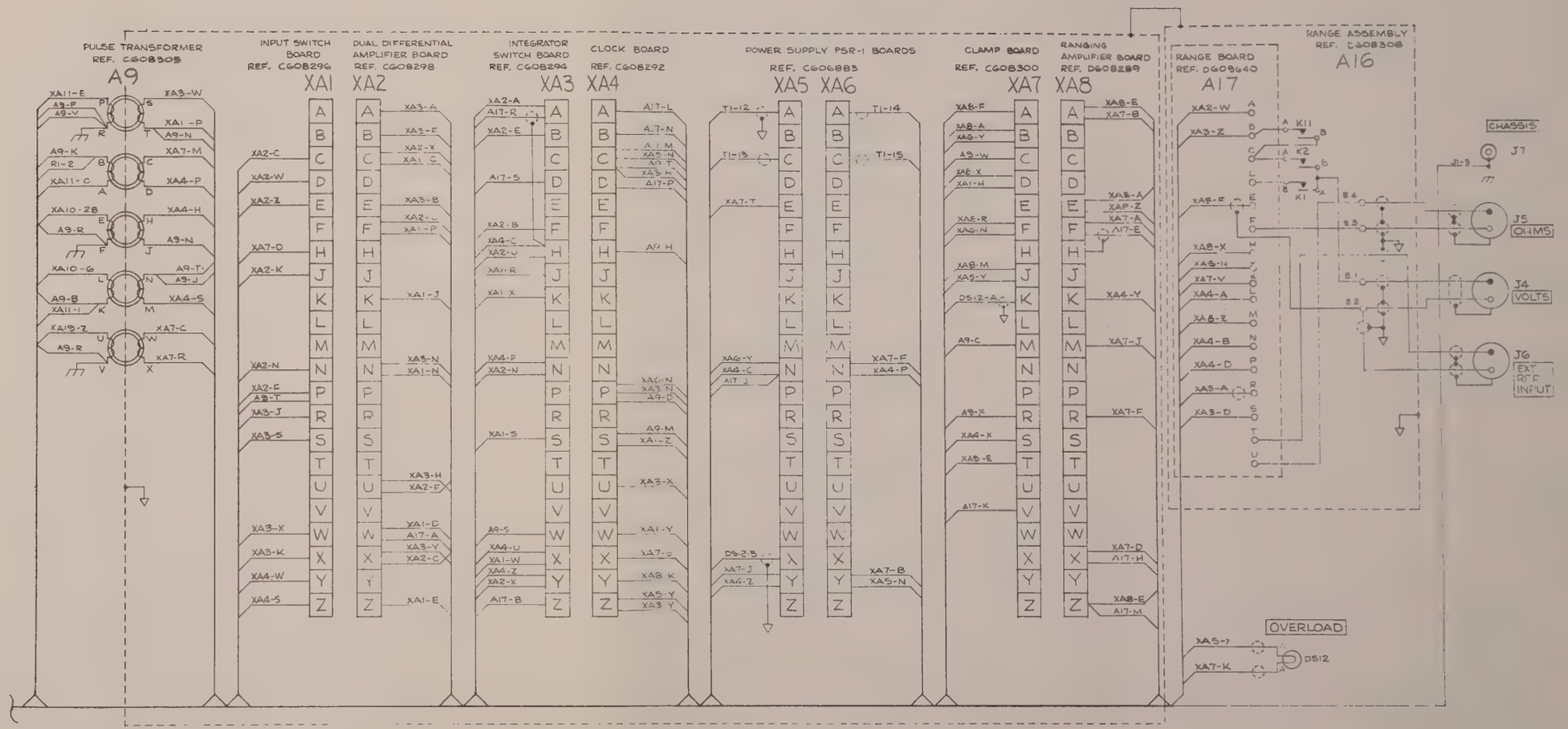

Figure E-7 Model 7111 Wiring Diagram
(Sheet 2 of 2)

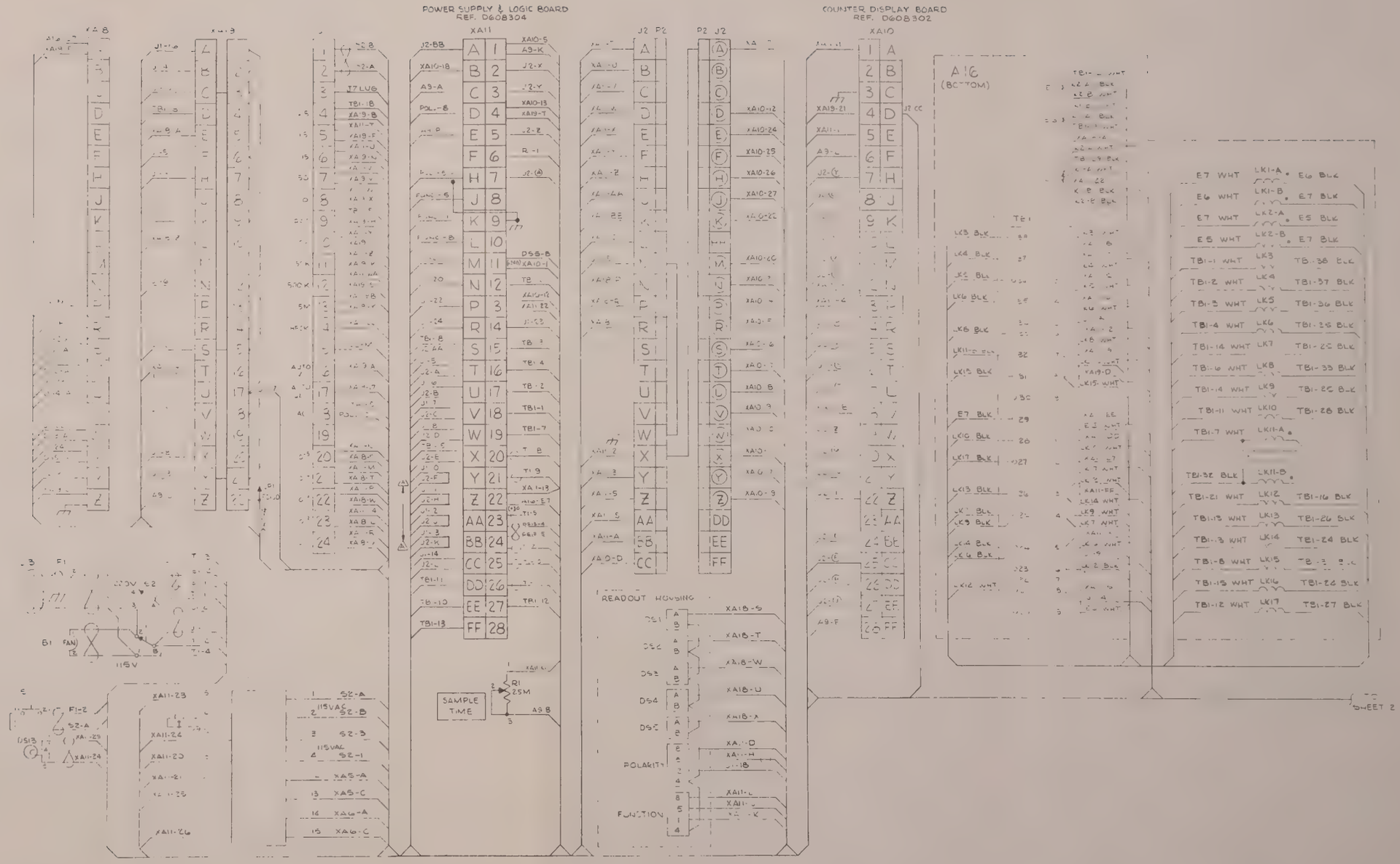

Figure E-8 Model 7120 Wiring Diagram
(Sheet 1 of 2)

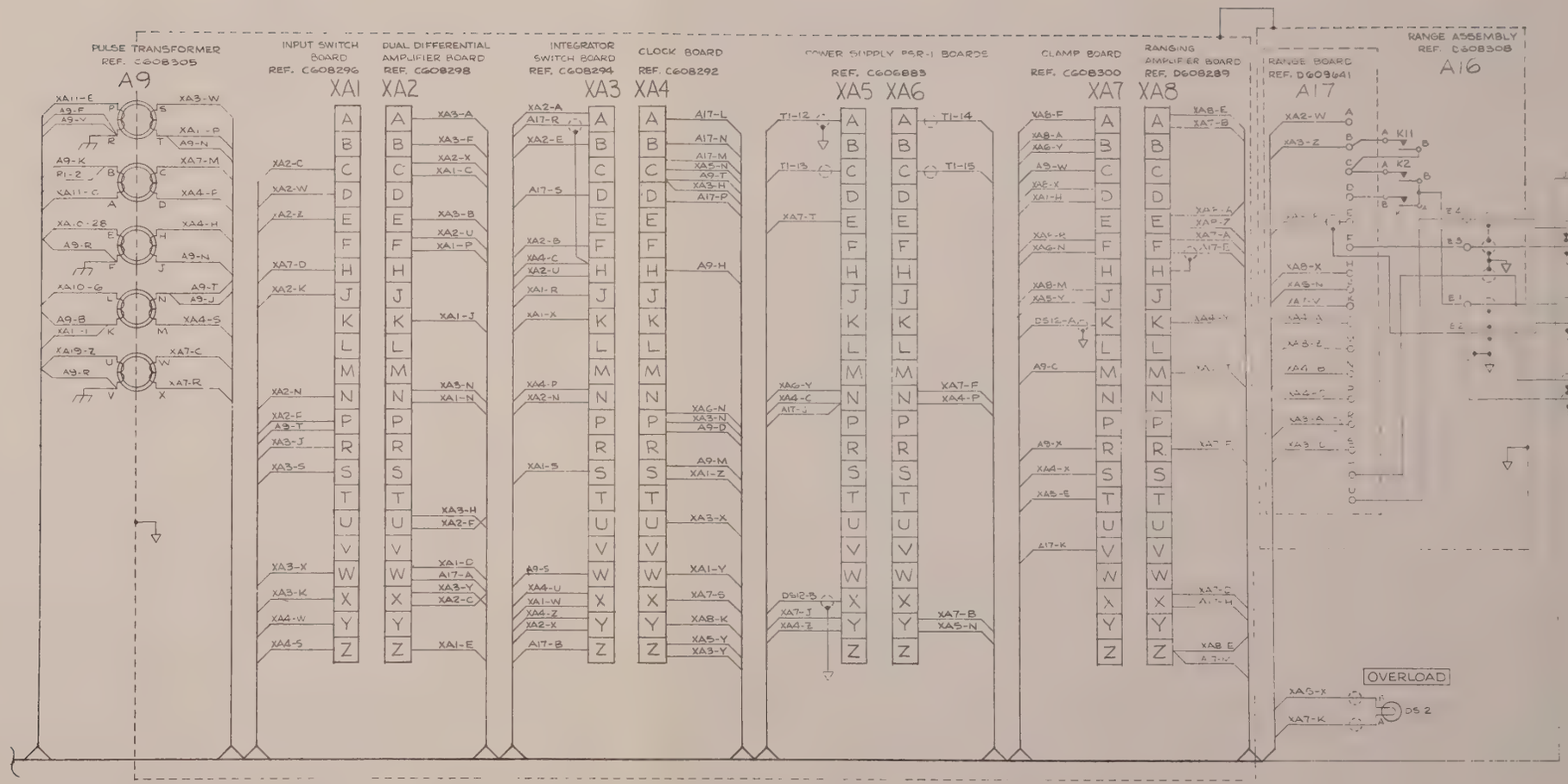

Figure E-8 Model 7121 Wiring Diagram (Sheet 2 of 2)

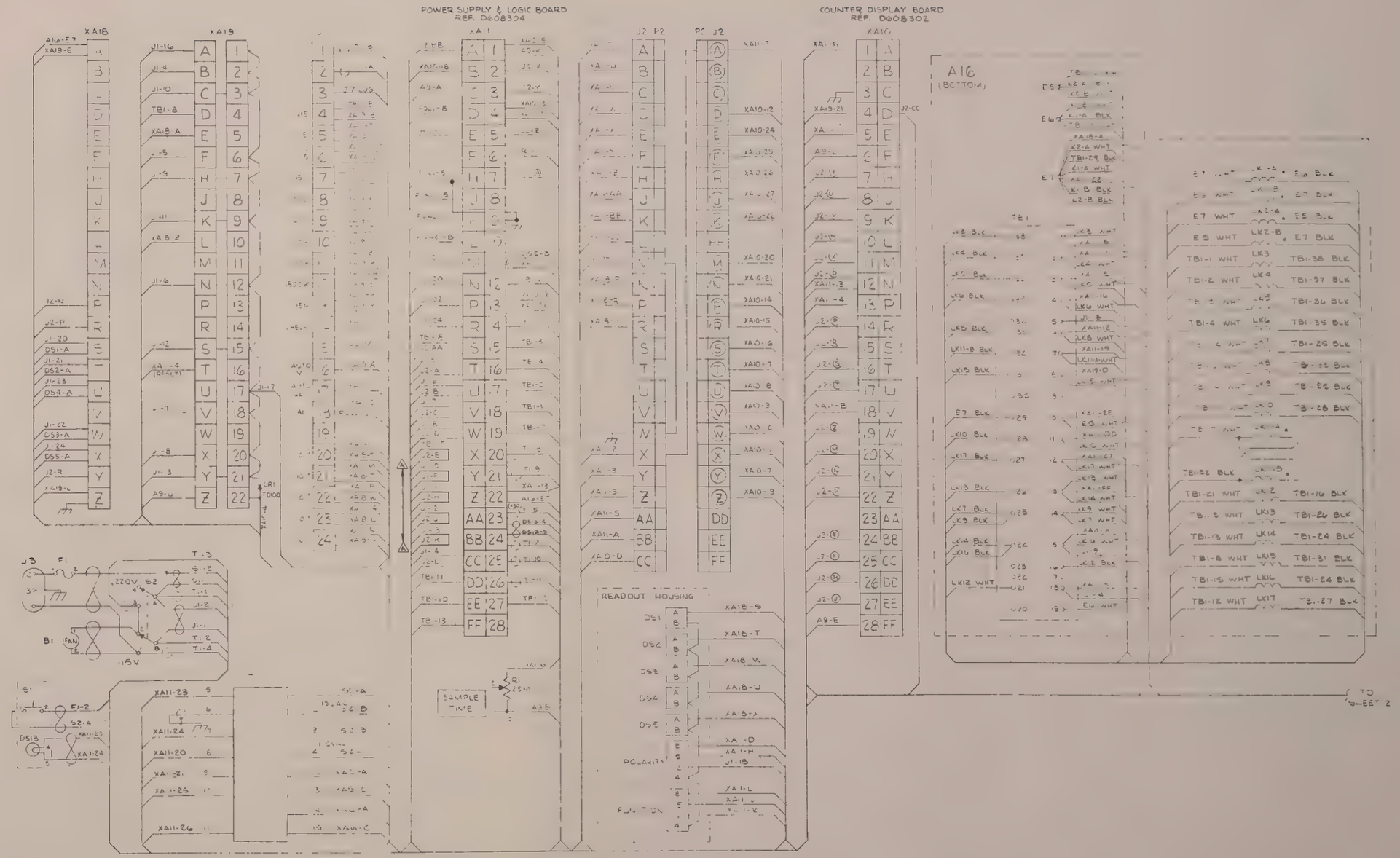

Figure E-9 Model 6141 Wiring Diagram
(Sheet 1 of 2)

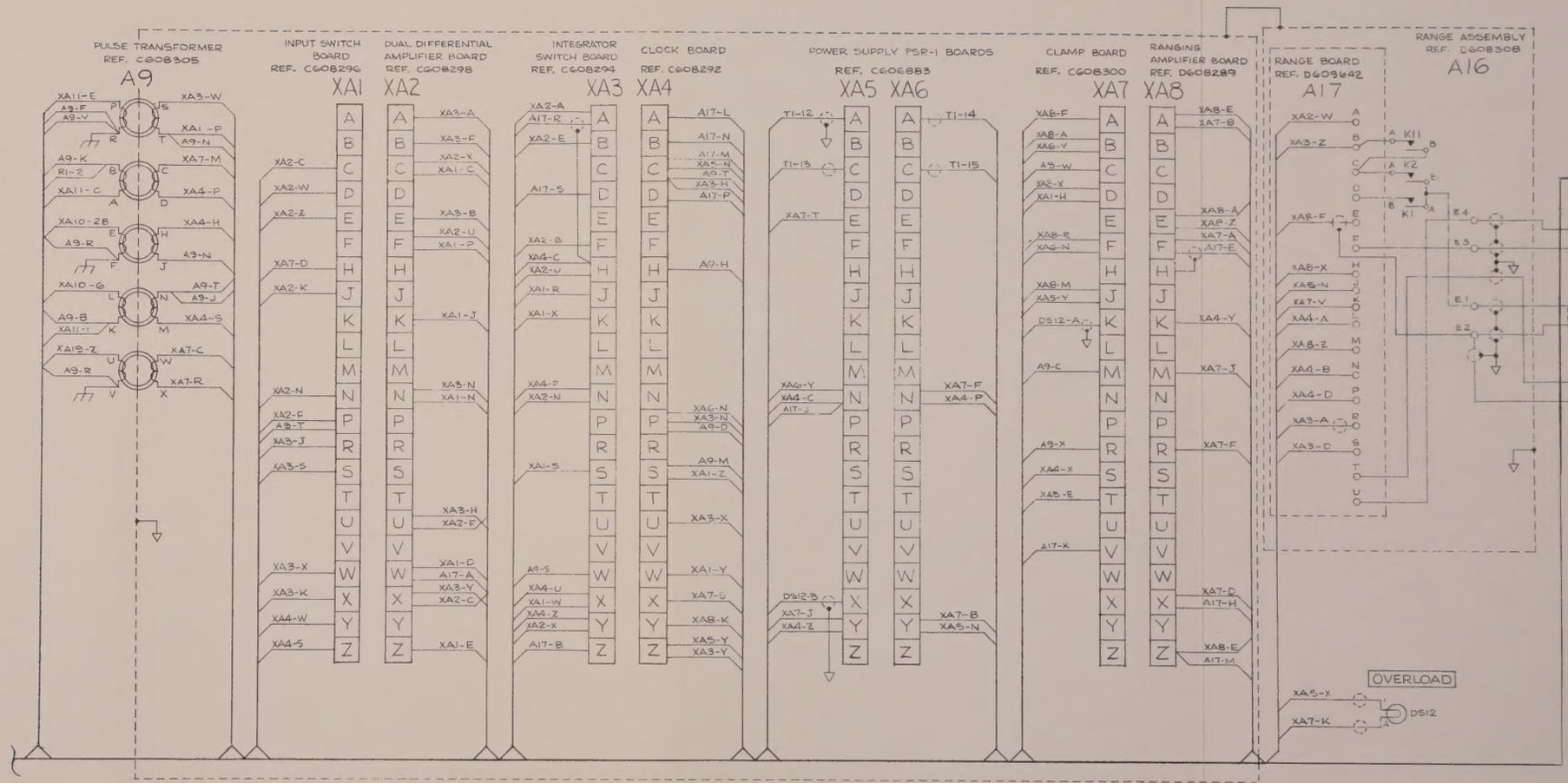

Figure E-9 Model 7141 Wiring Diagram

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